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TITLE: Design of a Screen-Based Simulation for Training and Automated Assessment of Teamwork Skills

PRINCIPAL INVESTIGATOR: Randolph Steadman

RECIPIENT: University of Los Angeles, CA
Los Angeles, CA 90095

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Introduction:
While communication and teamwork skills are increasingly recognized as important factors in improving patient safety, team training is not routinely incorporated into training programs, and opportunities to practice teamwork skills and receive objective feedback are limited. We are developing and testing a screen-based team training to provide healthcare professionals deliberate practice on teamwork skills and improve performance through automated feedback.
Methodology:
During year 2, we completed the domain ontology and study scenarios for the screen-based simulation system; incorporating findings from the qualitative research performed during year 1. Scenarios were scripted to incorporate specific teamwork skills and assessable actions for game scoring. An agile methodology is being used to design and develop the screen-based simulation game.
Results:
The learning objectives, settings and sequence of events were established for the three scenarios of the game. A prototype for the screen-based simulation system has been developed for both game-play and evaluation modes.
Conclusions:
In designing scenarios aimed at teaching teamwork skills in a medical context, it is important not to focus heavily on medical/technical performance elements so as not to overshadow the emphasis on teamwork skills. In terms of game development, an iterative approach has proven to yield the most utility.

15. SUBJECT TERMS					
Team training, assessment, screen-based simulation, communication, leadership, situation monitoring, mutual support, psychological safety					
16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** USAMRMC
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	Unclassified	28	**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified			

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Prescribed by ANSI Std. Z39.18

TABLE OF CONTENTS

1. **INTRODUCTION:** Narrative that briefly (one paragraph) describes the subject, purpose and scope of the research.

While communication and teamwork skills are increasingly recognized as important factors in improving patient safety, team training is not routinely incorporated into graduate training or continuing medical education programs. Opportunities to practice teamwork skills and receive objective feedback are limited. We are developing and testing a screen-based team training to provide healthcare professionals deliberate practice on teamwork skills and improve performance through automated, individualized feedback.

2. **KEYWORDS:** Provide a brief list of keywords (limit to 20 words).

Teamwork training, assessment, screen-based simulation, communication, leadership, situation monitoring, mutual support, psychological safety

3. **ACCOMPLISHMENTS:** The PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency Grants Officer whenever there are significant changes in the project or its direction.

What were the major goals of the project?
List the major goals of the project as stated in the approved SOW. If the application listed milestones/target dates for important activities or phases of the project, identify these dates and show actual completion dates or the percentage of completion.

- Major Task 1. Identify current team training practices, performance gaps, and resources (originally planned mos. 1-6, for revised completion based upon 6-month no-cost extension see below).
- Major Task 2. Create domain ontology and scenario scripts (originally planned mos. 5-8; for revised completion based upon 6-month no-cost extension see below).
- Major Task 3. Design a framework for online team training and assessment (originally planned mos. 8-11; for revised completion based upon 6-month no-cost extension see below).
- Major Task 4. Build the screen-based simulation (*Evaluation* and *Game-Play Modes*) (originally planned mos. 8-13; for revised completion based upon 6-month no-cost extension see below).
- Major Task 5. Conduct research using the screen-based simulation (originally planned mos. 6-8, 14-24; for revised completion based upon 6-month no-cost extension see below).

What was accomplished under these goals?
For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results or key outcomes, including major findings, developments, or conclusions (both positive and negative); and/or 4) other achievements. Include a discussion of stated goals not met. Description shall include pertinent data and graphs in sufficient detail to explain any significant results achieved. A succinct description of the methodology used shall be provided. As the project progresses to completion, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments.

For the purposes of this report:
Sim Team=Randolph Steadman, Yue Ming Huang, Rukhsana Khan and Maria Rudolph
Education Team=Noreen Webb, Federica Raia, Rachel Lewin and Michael Smith
CASIT (Center for Advanced Surgical & Interventional Technology) Team=Areti Tillou and Yen-Yi Juo
CRESST (Center for Research on Evaluation, Standards & Student Testing) Team=Alan Koenig, John Lee, Markus Iseli and Charles Parks

- Major Task 1. Identify team training practices, performance gaps and resources (mos. 1-14).
  - Subtask 1: Review research on existing team training literature, available products and best practices: 100% completed.
    - The purpose of this review was to examine existing literature, research, products, software, and tools to identify current team training practices and performance gaps during high stakes medical team activities. The review focused on areas of research that would be helpful for curricular framework and design of this project's screen-based simulation for training and automated assessment of teamwork skills.
    - We focused on the following topics: teamwork dimensions for team training, effectiveness of team training in healthcare, measuring acquisition of teamwork knowledge and skills, impact of teamwork training on teamwork knowledge and skills, teamwork attributes that are challenging to represent in a single player screen-based healthcare simulation, methods of simulation-based teamwork training, design issues related to authenticity of screen-based simulations, feedback and debriefing in simulated teamwork settings, screen-based simulations versus high fidelity simulators, and screen-based simulations teaching teamwork in medical settings.
    - Major findings for this review will be summarized in Subtask 5, along with a description of the methodology used.
  - Subtask 2: Perform video analysis of medical teams in action: 100% completed.
    - Videos of critical incidents (real and simulated) were reviewed by all members of the research team.
    - Videos were used to develop consensus of what the observable, assessable teamwork actions are in critical care.
    - Challenges were categorized into the following areas of opportunity for improvement: a) communication issues as they relate to noise control, handoffs, closed-loop communication, leadership and anticipating/sharing plan; and b) process issues related to role clarity and delegation.
  - Subtask 3: Interview Subject Matter Experts (SMEs) and healthcare practitioners. 100% completed.
    - The purpose of the SME interviews was to gather information from team training experts to help ascertain the strengths, weaknesses and limitations of teamwork training approaches and factors that contribute to the breakdown of teamwork processes. The research team also solicited input from SMEs on the proposed team training framework and core teamwork skills that will be incorporated in the screen-based simulation game.
    - The interviews were conducted in a semi-structured format and led by Michael Smith, due to his expertise in applied linguistics.

- We interviewed the following team training subject matter experts: David Gaba, MD, creator of Anesthesia Crisis Resource Management; David Baker, developer of TeamSTEPPS; Andrea Amodeo, TeamSTEPPS researcher; and John Holcomb, MD, a combat surgery expert. Although not formally named as an SME on this grant, the team also interviewed Christopher Hund, Director of Clinical Quality for the Health Research & Educational Trust (HRET) due to his expertise in directing TeamSTEPPS projects.
- Close analysis of the SME interviews helped inform the research team on the following: which context is teamwork crucial, what skills are important for high acuity settings, what undermines teamwork, traits and practices for a "good" team player, challenges to teaching teamwork, advantages and pitfalls of TeamSTEPPS, educational tools for teaching teamwork and military implications that affect teamwork.
- Major findings from SME interviews will be summarized in Subtask 5.

➢ Subtask 4: Conduct/analyze focus groups of healthcare teams: 100% completed.
- The purpose of the focus group interviews was to gather honest impressions about teamwork and communication from healthcare professionals who work in team settings at Ronald Reagan UCLA Medical Center. The intention was to have a conversation with front-line medical personnel about their personal experience as a team leader/ and or supportive team member, in order to help inform our game development.
- Four focus group interviews took place between June of 2017 and July of 2017. All interviews were audio recorded with consent from participants. Rachel Lewin and Maria Rudolph conducted the interviews; Ms. Lewin was the primary interviewer and Dr. Rudolph was the secondary interviewer and recorder. Focus groups were comprised of 3-6 front-line medical personnel, including Emergency Medicine and Internal Medicine physicians, respiratory therapists, and ICU and Trauma Surgery nurses.
- A few recurrent themes were gathered from the interviews including introduction styles from team members, roles/structure of teams, psychological safety to encourage feedback, and clear communication. A formal narrative of findings will be included under Subtask 5.

➢ Subtask 5: Prepare report of current practices and gaps in team training. 90% completed.
- A draft of our findings for the literature review, SME interviews and focus group interviews is attached in Appendices section. We are currently working on making it one cohesive report.

❖ Major Task 2. Create domain ontology and scenario scripts (mos.5-21).

➢ Subtask 1: Create team training core skills domain ontology: 100% completed.
- Following completion of video review, the Sim, CASIT and CRESST teams began meeting weekly to create a list of all possible assessable teamwork actions pertinent to patient care. This list will inform the assessable actions used in the screen-based simulation.
- A final version of the domain ontology was developed based on the assessable teamwork skills and actions that were identified. Since the last quarterly report, a few modifications regarding the relationship between certain actions and teamwork skills have been made.

- Subtask 2: Create a set of features, affordances, and actions for user interface: 100% completed.
  - Using the game development software, Unity, an early test environment for the game was developed to highlight potential interactivity elements.
  - Acquired 3D assets (game avatars) including hospital room and medical personnel.
  - Worked on modes of interactivity for the user interface (e.g., how to direct communication to the desired avatar).
  - Presented a mock-up of the first scenario to the research team for feedback on interactivity elements and sequencing of events. Currently working on refining interactivity elements based on research team's feedback.
  - Developed an Action Level Ontology that includes possible actions and the related game mechanics.
- Subtask 3: Create a range of scenario settings/events: 100% completed.
  - A subset of the research team composed of the Sim Team and CRESST, met to establish the learning objectives, setting, sequence of events and player affordances for each of the three scenarios of the game.
  - It was decided that each scenario will focus on teaching teamwork leadership skills in the settings of the trauma bay, OR, and ICU.
  - An inventory of skills appropriate for the scope of practice for the roles of the player and non-player characters (NPCs) for each scenario was also created.
- Subtask 4: Create a knowledge assessment (baseline team skills) scenario: 100% completed.
  - The baseline scenario (trauma bay MVA) will serve as a pretest for player/student Knowledge, Skills and Abilities (KSAs); assessing the player's knowledge and skills related to teamwork without any feedback until after scenario completion.
- Subtask 5: Create 3 scenarios with different settings, events and skill requirements: 100% completed.
  - The research team brainstormed a series of events and skill requirements for incorporation into the game. As stated under Subtask 3 above, the learning objectives, setting and sequence of events for all 3 scenarios of the game have been created.
  - Subsequent scenarios have been completed (OR and ICU), and are following the same model and structure used for this first scenario. We have incorporated the information gathered from the SME and focus group interviews into each of these subsequent scenarios.
  - All scenarios include the same basic and advanced teamwork skills, including communication, problem resolution, and team management.

❖ Major Task 3. Design a framework for online team training and assessment (mos. 8-26).

- Subtask 1: Design the automatic assessment engine: 98% completed
  - A Bayesian Network (BN) has been created from the ontologies. The BN is used to infer competencies related to the teamwork skill constructs. The main constructs (top level nodes) include: leadership, situation monitoring, communication, mutual support / conflict resolution, and resource management. At the observable level, there are the types of actions the player can take and the components of each action that the simulation captures and scores.
- Subtask 2: Design the simulation interface: 100% completed.
  - Gameplay mode: The simulation interface includes several affordances through which the player can carry out various actions.
  - Evaluation mode: The interface looks mostly similar to the Gameplay mode, with differences being that this mode will have preset pause points for the player to provide feedback via multiple choice questions about noteworthy teamwork skills observed (correctly or incorrectly).

- Subtask 3: Design the after-action review (AAR): 98% completed.
  - Player performance will be presented and explained, including evaluation of player actions with descriptive feedback, and general instruction on the specific team skills required in the game scenario.
  - We have finished developing the content that will be presented in the AAR for both simulation modes. The content covers the following teamwork principles: communication; leadership; situation monitoring; and mutual support. The AAR also includes reflection questions and test questions that will assess the player's knowledge of key teamwork concepts. Currently making wording refinements and cross-referencing sources.
- Subtask 4: Pilot storyboard workflows for quality assurance piloting: 100% completed.
  - Storyboarding is complete, but due to the iterative nature of software development, we are continually piloting and refining features.

❖ Major Task 4: Build screen based simulation (Evaluation and Gameplay modes) (mos. 8-26).
- Subtask 1: Develop software specifications: 95% complete.
  - Agile development of software specifications based on use-cases, with specific associated development sub-tasks. Process consists of Specify -> Develop -> Test -> Iterate/Refine, which inter-links Subtasks 1, 2, and 3. For a description of the software specifications, please refer to file named "Software Specifications Teamwork v6" in Appendices section.
- Subtask 2: Develop software-based prototype of two simulation modes: 95% complete.
  - Development is occurring using an agile development methodology (see Subtask 1, above).
  - We have completed the authoring and development of all 3 scenarios of evaluation mode. For game-play mode, we have finished authoring all 3 scenarios and are currently finishing the programming of scenarios 2 and 3. Scenario 1 of game-play mode is complete, but being refined based on feedback from the research team.
  - Since we are behind schedule on the programming, we have brought on additional programming support and implemented weekly sprint meetings to set weekly programming goals and track progress of software development.
- Subtask 3: Perform software testing for quality assurance: 95% complete.
  - Testing is occurring using an agile development methodology (see Subtask 1, above).
  - Weekly builds of the game are sent to the research team for quality testing. Issues and bugs are managed through the web-based application, Bitbucket. We are currently working on debugging scenarios in both evaluation and game-play mode.

❖ Major Task 5. Conduct research using the screen-based simulation (mos. 6-8, 21-30).
- Subtask 1: Obtain IRB approval from UCLA and USAMRMC HRPO: 100% completed.
  - We submitted the UCLA IRB application in December 2016 and received approval on February 15, 2017. We also submitted a Protocol Submission Form for USAMRMC HRPO on March 28, 2017 and received approval on May 11, 2017. A continuing review application was submitted to the UCLA IRB on December 19, 2017 and was approved on December 21, 2017. A copy of the IRB continuing review approval letter was sent to USAMRMC HRPO. We are in the process of submitting an amendment to the UCLA IRB and USAMRMC HRPO to expand our subject recruitment pool. No study activities have taken place yet.
- Subtask 2: Recruit subjects to test screen-based simulation: 0% complete.
  - Recruitment of subjects to test our screen-based simulation is contingent upon completion and piloting of the screen-based simulation system. We plan to start recruiting subjects in September of 2018.
- Subtask 3: Conduct follow up Interviews with select subjects: 0% complete.
  - Follow-up interviews of subjects is contingent upon completion of subtask 2 above.
- Subtask 4: Perform quantitative and qualitative data analysis: 0% complete.
  - We plan to start data analysis in December of 2018.
- Subtask 5: Prepare and deliver final report: 0% complete.
  - Completion of this task is contingent upon completion of subtasks 2-4 above.

What opportunities for training and professional development has the project provided?
If the project was not intended to provide training and professional development opportunities or there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe opportunities for training and professional development provided to anyone who worked on the project or anyone who was involved in the activities supported by the project. "Training" activities are those in which individuals with advanced professional skills and experience assist others in attaining greater proficiency. Training activities may include, for example, courses or one-on-one work with a mentor. "Professional development" activities result in increased knowledge or skill in one's area of expertise and may include workshops, conferences, seminars, study groups, and individual study. Include participation in conferences, workshops, and seminars not listed under major activities.

Nothing to Report.

How were the results disseminated to communities of interest?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how the results were disseminated to communities of interest. Include any outreach activities that were undertaken to reach members of communities who are not usually aware of these project activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Nothing to Report.

What do you plan to do during the next reporting period to accomplish the goals?
If this is the final report, state "Nothing to Report."

Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.

The research team plans to continue holding weekly team meetings to meet the goals of the project. We also plan to continue with our weekly sprint meetings to monitor progress of software development goals. The deadline for software development is end of August. This allows time for recruitment, data collection, analysis and reporting prior to mid-January 2019. We are using the web-based application, Bitbucket, to manage programming bugs and enhancements; setting priorities for each so they are accomplished within our set deadlines. In order to complete our research study within the project deadline, we have compressed the data collection period to 3 months. To meet our targeted enrollment number over this shorter period of time, we are in the process of submitting an amendment to the IRB to expand our subject recruitment pool. We plan to expand recruitment to military settings, the wider UCLA Health System and other institutions using our same inclusion criteria (licensed healthcare professionals). This will help make our study results more generalizable and applicable to the military health system.

4. **IMPACT:** Describe distinctive contributions, major accomplishments, innovations, successes, or any change in practice or behavior that has come about as a result of the project relative to:

What was the impact on the development of the principal discipline(s) of the project?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research in the principal disciplinary field(s) of the project. Summarize using language that an intelligent lay audience can understand (Scientific American style).

Nothing to Report.

What was the impact on other disciplines?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines.

We anticipate that this study will inform the defense community and private sector on the effectiveness of screen-based simulation for teamwork skills training of healthcare providers. We also hope to provide the design methodology for the development of screen-based simulation training on other topics and for other disciplines.

What was the impact on technology transfer?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use, including:

- *transfer of results to entities in government or industry;*
- *instances where the research has led to the initiation of a start-up company; or*
- *adoption of new practices.*

This project will provide the design methodology for the development of screen-based simulation training and the potential to convert this training to virtual reality.

What was the impact on society beyond science and technology?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world on areas such as:

- *improving public knowledge, attitudes, skills, and abilities;*
- *changing behavior, practices, decision making, policies (including regulatory policies), or social actions; or*
- *improving social, economic, civic, or environmental conditions.*

Nothing to Report.

5. **CHANGES/PROBLEMS:** The Project Director/Principal Investigator (PD/PI) is reminded that the recipient organization is required to obtain prior written approval from the awarding agency Grants Officer whenever there are significant changes in the project or its direction. If not previously reported in writing, provide the following additional information or state, "Nothing to Report," if applicable:

Changes in approach and reasons for change
Describe any changes in approach during the reporting period and reasons for these changes. Remember that significant changes in objectives and scope require prior approval of the agency.

Nothing to Report.

Actual or anticipated problems or delays and actions or plans to resolve them
Describe problems or delays encountered during the reporting period and actions or plans to resolve them.

Although we have made significant progress in game development, we did not accurately estimate the amount of time it would take to program and debug scenarios. This has unfortunately caused delays. To mitigate the risk of falling behind schedule, we onboarded additional programming support from the software development company, SimInsights Inc. We are also holding weekly sprint meetings to check progress of software development, set weekly software development goals and prioritize features and bugs that can be programmed/fixed within the sprint. Programmers are releasing a weekly software build that incorporates bug fixes discussed at the sprint meeting. This approach has allowed the research team to test and refine the game in quick, 1-week cycles. We have also started using Bitbucket to easily track and manage programming tasks. To address the delay in data collection, we are in the process of submitting an IRB addendum to identify other sources for subject recruitment using the same inclusion criteria described in our original proposal. This will enable us to collect more data over a shorter period of time.

Describe changes during the reporting period that may have had a significant impact on expenditures, for example, delays in hiring staff or favorable developments that enable meeting objectives at less cost than anticipated.

In order to meet our programming needs, we hired SimInsights Inc. as programmer consultants. We repurposed some SME consultant money to fund this additional programming. We are using volunteer SMEs for piloting our game.

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Describe significant deviations, unexpected outcomes, or changes in approved protocols for the use or care of human subjects, vertebrate animals, biohazards, and/or select agents during the reporting period. If required, were these changes approved by the applicable institution committee (or equivalent) and reported to the agency? Also specify the applicable Institutional Review Board/Institutional Animal Care and Use Committee approval dates.

Significant changes in use or care of human subjects

Nothing to Report.

Significant changes in use or care of vertebrate animals.

Nothing to Report

Significant changes in use of biohazards and/or select agents

Nothing to Report

6. **PRODUCTS:** List any products resulting from the project during the reporting period. If there is nothing to report under a particular item, state "Nothing to Report."

- **Publications, conference papers, and presentations**
  Report only the major publication(s) resulting from the work under this award.

  Journal publications. *List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Nothing to Report.

  Books or other non-periodical, one-time publications. *Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like. Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (e.g., book, thesis or dissertation); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Presented a poster at the American Educational Research Association (AERA) 2018 Annual Meeting. See file "AGILE Methodology for Developing a Game-Based Assessment of Teamwork Skills" in appendices section below. **Authors:** Markus Iseli, PhD, Alan D. Koenig, PhD, John J. Lee, PhD, Rachel Lewin and Randolph Steadman, MD, MS **Title of Poster:** AGILE Methodology for Developing a Game-Based Assessment of Teamwork Skills **Type of Publication:** Poster presentation

  Other publications, conference papers, and presentations. *Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication as noted above. List presentations made during the last year (international, national, local societies, military meetings, etc.). Use an asterisk (*) if presentation produced a manuscript.*

Nothing to Report.

- **Website(s) or other Internet site(s)**
  List the URL for any Internet site(s) that disseminates the results of the research activities. A short description of each site should be provided. It is not necessary to include the publications already specified above in this section.

Nothing to Report.

- **Technologies or techniques**
  Identify technologies or techniques that resulted from the research activities. In addition to a description of the technologies or techniques, describe how they will be shared.

Nothing to Report.

- **Inventions, patent applications, and/or licenses**
  Identify inventions, patent applications with date, and/or licenses that have resulted from the research. State whether an application is provisional or non-provisional and indicate the application number. Submission of this information as part of an interim research performance progress report is not a substitute for any other invention reporting required under the terms and conditions of an award.

Nothing to Report.

- **Other Products**
  Identify any other reportable outcomes that were developed under this project. Reportable outcomes are defined as a research result that is or relates to a product, scientific advance, or research tool that makes a meaningful contribution toward the understanding, prevention, diagnosis, prognosis, treatment, and/or rehabilitation of a disease, injury or condition, or to improve the quality of life. Examples include:
  - *data or databases;*
  - *biospecimen collections;*
  - *audio or video products;*
  - *software;*
  - *models;*
  - *educational aids or curricula;*

- *instruments or equipment;*
- *research material (e.g., Germplasm; cell lines, DNA probes, animal models);*
- *clinical interventions;*
- *new business creation; and*
- *other.*

Nothing to Report.

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?
Provide the following information for: (1) PDs/PIs; and (2) each person who has worked at least one person month per year on the project during the reporting period, regardless of the source of compensation (a person month equals approximately 160 hours of effort). If information is unchanged from a previous submission, provide the name only and indicate "no change."

Example:

Name:	*Mary Smith*
Project Role:	*Graduate Student*
Researcher Identifier (e.g. ORCID ID):	*1234567*
Nearest person month worked:	*5*
Contribution to Project:	*Ms. Smith has performed work in the area of combined error-control and constrained coding.*
Funding Support:	*The Ford Foundation (Complete only if the funding support is provided from other than this award).*

Name: Randolph Steadman, MD, MS
Project Role: Principal Investigator
Researcher Identifier: N/A
Nearest person month worked: 2.29
Contribution to Project: Dr. Steadman has performed work in the area of literature review, product review and video analysis. He serves as clinical content expert for development of game scenarios and created content for the after-action review. He has also provided direction and oversight of the project as principal investigator.

Name: Yue Ming Huang, EdD, MHS
Project Role: Co-Investigator; Project Manager
Researcher Identifier: N/A
Nearest person month worked: 1.75
Contribution to Project: Dr. Huang has overseen the administration and management of the project. She has also performed work in the area of literature and product review, video analysis, game design and objectives and created content for the after-action review.

Name: Rukhsana Khan, MPH
Project Role: Research Assistant
Researcher Identifier: N/A
Nearest person month worked: 2.21
Contribution to Project: Ms. Khan has provided assistance in project management. She has also performed work in the area of literature and product review, video analysis, game development and completion of IRB application.

Name: Noreen Webb, PhD
Project Role: Co-Investigator
Researcher Identifier: N/A
Nearest person month worked: 0.22
Contribution to Project: Dr. Webb has performed work in the area of literature and product review, video analysis and provided input for game design and objectives. She has also provided guidance over the scoring criteria for the game.

Name: Federica Raia, PhD
Project Role: Co-Investigator
Researcher Identifier: N/A
Nearest person month worked: 0.35
Contribution to Project: Dr. Raia has performed work in the area of literature and product review, video analysis and provided input for game design and objectives. She has also helped write the literature review report.

Name: Rachel Lewin
Project Role: Graduate Student Researcher
Researcher Identifier: N/A
Nearest person month worked: 3.0
Contribution to Project: Ms. Lewin has performed work in the area of literature and product review, video analysis and provided input for game design and objectives. She also led focus group interviews of healthcare teams and helped summarize those findings. She has also helped develop and author scenarios for both simulation modes.

Name: Michael Smith
Project Role: Graduate Student Researcher
Researcher Identifier: N/A
Nearest person month worked: 3.0
Contribution to Project: Mr. Smith has performed work in the area of literature and product review, video analysis and provided input for game design and objectives. He also led subject matter expert interviews and helped write a summary of those findings.

Name: Markus Iseli, PhD
Project Role: Co-Investigator
Researcher Identifier: N/A
Nearest person month worked: 1.44
Contribution to Project: Mr. Iseli has helped plan and design the domain ontology and screen-based simulation interface.

Name: Alan Koenig, PhD
Project Role: Co-Investigator
Researcher Identifier: N/A
Nearest person month worked: 1.46
Contribution to Project: Dr. Koenig has provided leadership over the planning and design of the domain ontology and screen-based simulation interface.

Name: John Lee, PhD
Project Role: Co-Investigator
Researcher Identifier: N/A
Nearest person month worked: 1.56
Contribution to Project: Mr. Lee has managed the CRESST team's deliverables specifically pertaining to the design and development of domain ontology and screen-based simulation interface.

Name: Charles Parks
Project Role: Programmer
Researcher Identifier: N/A
Nearest person month worked: 1.98
Contribution to Project: Mr. Parks has performed work in framework design and programming test environments for the screen-based simulation game.

Name: Yen-Yi Juo, MD
Project Role: Research Fellow
Researcher Identifier: N/A
Nearest person month worked: 1.29
Contribution to Project: Dr. Juo has provided clinical direction in the development of potential game scenarios and its objectives. He has concluded his role on the project now that project year 2 is complete.

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

If the active support has changed for the PD/PI(s) or senior/key personnel, then describe what the change has been. Changes may occur, for example, if a previously active grant has closed and/or if a previously pending grant is now active. Annotate this information so it is clear what has changed from the previous submission. Submission of other support information is not necessary for pending changes or for changes in the level of effort for active support reported previously. The awarding agency may require prior written approval if a change in active other support significantly impacts the effort on the project that is the subject of the project report.

Nothing to Report.

What other organizations were involved as partners?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe partner organizations – academic institutions, other nonprofits, industrial or commercial firms, state or local governments, schools or school systems, or other organizations (foreign or domestic) – that were involved with the project. Partner organizations may have provided financial or in-kind support, supplied facilities or equipment, collaborated in the research, exchanged personnel, or otherwise contributed.
Provide the following information for each partnership:
Organization Name:
Location of Organization: (if foreign location list country)
Partner's contribution to the project (identify one or more)

- *Financial support;*
- *In-kind support (e.g., partner makes software, computers, equipment, etc., available to project staff);*
- *Facilities (e.g., project staff use the partner's facilities for project activities);*
- *Collaboration (e.g., partner's staff work with project staff on the project);*
- *Personnel exchanges (e.g., project staff and/or partner's staff use each other's facilities, work at each other's site); and*
- *Other.*

Organization Name: Siminsights Inc.

Location of Organization: 20381 Lake Forest Drive, Suite B15, Lake Forest, CA 92630

Partner's contribution to the project: Collaboration.
Partner provides programming support for the development of our screen-based simulation.

8. SPECIAL REPORTING REQUIREMENTS

COLLABORATIVE AWARDS: For collaborative awards, independent reports are required from BOTH the Initiating PI and the Collaborating/Partnering PI. A duplicative report is acceptable; however, tasks shall be clearly marked with the responsible PI and research site. A report shall be submitted to **https://ers.amedd.army.mil** for each unique award.

QUAD CHARTS: If applicable, the Quad Chart (available on https://www.usamraa.army.mil) should be updated and submitted with attachments.

9. APPENDICES: Attach all appendices that contain information that supplements, clarifies or supports the text. Examples include original copies of journal articles, reprints of manuscripts and abstracts, a curriculum vitae, patent applications, study questionnaires, and surveys, etc.

Design of a Screen-Based Simulation for Training and Automated Assessment of Teamwork Skills

Log Number: DM142062

Award Number: W81XWH-16-1-0308

PI: Randolph Steadman, MD **Org:** University of California, Los Angeles **Award Amount:** $1,148,000

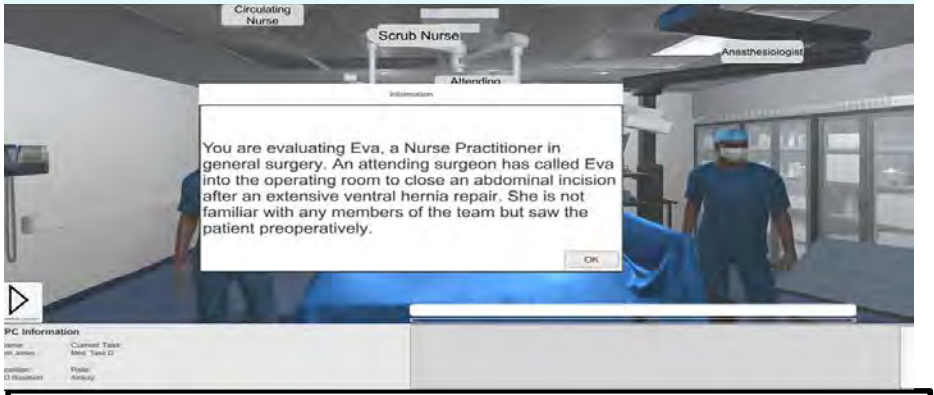
Study/Product Aim(s)

- **Aim 1**: Identify team training practices, performance gaps and resources
- **Aim 2**: Create domain ontology (necessary actions, decisions and their inter-relationships) and scenario scripts
- **Aim 3:** Design a framework for online team training and assessment
- **Aim 4**: Build screen-based simulation (evaluation and game-play modes)
- **Aim 5:** Conduct research study using the screen-based simulation

Approach

A literature review will identify gaps in team training, limitations of current training methods and essential behavioral skills. This phase will identify the core teamwork skills that will be the focus of the simulation-based systems we develop. We will then create the ontology and scenario scripts and conceptualize the framework for the screen-based simulation. Finally, we will evaluate the training effectiveness and user interface of the screen-based simulation systems.

Interface of scenario 2 for evaluation mode



Accomplishment: We have completed the programming of evaluation mode for our screen-based simulation and made significant progress for game-paly mode. We have also finished developing content for the after-action review.

Timeline and Cost

Specific Aims/ Tasks/ Milestones	Planned Month	% Completion	Revised timeline as of Month 24 (completion date)
1. Identify current team training practices, performance gaps and resources	1-6		1-14
1A. Review existing research, products and best practices	1-2	100%	N/A
1B. Perform video review analysis of medical teams in action	1-4	100%	N/A
1C. Interview SMEs and healthcare practitioners	4-5	100%	N/A
1D. Conduct/analyze focus groups of healthcare teams	5-6	100%	N/A
1E. Prepare report of current practices and gaps in team training **(Deliverable)**	2-6	90%	2-14 (9/2017)
2. Create domain ontology and scenario scripts	5-8		5-21
2A. Create team training core skills domain ontology	5-7	100%	N/A
2B. Create set of features, affordances and actions for user interface	6-8	100%	N/A
2C. Create range of scenario settings/events	6-8	100%	6-16 (11/2017)
2D. Create a knowledge assessment (baseline team skills) scenario	7-8	100%	7-16 (11/2017)
2E. Create 3 scenarios with different settings, events, skills requirements	7-8	100%	7-21 (4/2018)
3. Design a framework for online team training and assessment	8-11		8-26
3A. Design the automatic assessment engine	8-9	98%	26 (8/31/2018)
3B. Design the simulation interface	8-10	100%	26 (8/31/2018)
3C. Design the after-action reporting	10	98%	26 (8/31/2018)
3D. Pilot storyboard workflows for quality assurance piloting	9-11	100%	26 (8/31/2018)
4. Build screen-based simulation (Evaluation and Game-Play modes)	8-13		8-26
4A. Develop software specifications	8	95%	26 (8/31/2018)
4B. Develop software-based prototype of two simulation modes	9-13	95%	26 (8/31/2018)
4C. Perform software testing for quality assurance	12-13	95%	26 (8/31/2018)
5. Conduct research study using screen-based simulation	6-8, 14-24		6-8, 21-31
5A. Obtain IRB approval from UCLA and USAMRMC HRPO	6-8	100%	N/A
5B. Recruit subjects to test screen-based simulation	14-22	0%	27-29 (9-11/2018)
5C. Conduct follow up Interviews with select subjects	16, 19, 22	0%	28-29 (10-11/2018)
5D. Perform quantitative and qualitative data analysis	22-23	0%	30-31(12/2018-1/2019)
5E. Prepare and deliver final report **(Deliverable)**	22-24	0%	30-31(12/2018-1/2019)
6. Write manuscript for publication (Deliverable)	6,7,11,12, 18,19,23,2		27-31
Estimated Budget ($K)			

CY 2016	CY 2017	CY 2018	6 Mo. Extension
$313	$574	$261	$0

Updated: (08/03/2018)

Goals/Milestones

CY16 Goal – Gap analysis

- ☑ Literature and video review
- ☑ Interview subject matter experts and focus groups

CY17 Goals – Complete screen-based simulation

- ☑ Complete domain ontology and study scenarios
- ☐ Complete framework design for online team training and assessment
- ☐ Complete programming of the interactive environment
- ☐ Recruit subjects to test screen-based simulation

CY18 Goal – Complete research data collection

- ☐ Continue to recruit subjects
- ☐ Perform qualitative and quantitative data analysis

Comments/Challenges/Issues/Concerns:

Encountered delays in programming and scenario development, which has delayed subject recruitment.

Budget Expenditure to Date

Projected Expenditure: $1,148,000

Actual Expenditure: $999,164.96

Literature Review (Team Training Research)

Introduction

The purpose of this review was to examine existing literature, research, products, software, and tools to identify current team training practices and performance gaps during high stakes medical team activities. The review focused on areas of research that would be helpful for curricular framework and design of this project's screen-based simulation for training and automated assessment of teamwork skills (ontology design, definition of instructional objectives, assessment design, and scenario development). We focused on the following topics:

1) teamwork dimensions for team training
2) effectiveness of team training in healthcare
3) measuring acquisition of teamwork knowledge and skills
4) impact of teamwork training on teamwork knowledge and skills
5) teamwork attributes that are challenging to represent in a single player screen-based healthcare simulation
6) methods of simulation-based teamwork training: observational (vicarious) versus participatory learning
7) design issues related to authenticity of screen-based simulations
8) feedback and debriefing in simulated teamwork settings
9) screen-based simulations versus high fidelity simulators
10) screen-based simulations teaching teamwork in medical settings

Methods

The first part of the literature review was a scoping review of teamwork, team training, simulation, feedback, measurement, and outcomes, with special emphasis on gaming environments and the healthcare context. First, content experts identified highly relevant literature. Our search was expanded based on the references from this literature. Second, we completed an extensive search in PubMed, CINAHL, PsycINFO, ERIC, and Business Source Premier in the following areas:

1) Transferability of skill training and feedback
2) Methods in computer gaming, virtual reality, and team training

This extensive search yielded approximately 6,000 results. Using keywords we identified 1,500 of the most relevant articles for further scrutiny. A number of the excluded articles were considered to ensure that relevant articles were not being excluded. These 1,500 articles were then used to create this scoping review. Search terms and keywords can be found in [Appendix A].

The second portion of our review analyzed research in simulated environments with the purpose of identifying issues especially germane to the design of single-player screen-based

simulations. The primary research areas examined were:

1) human-computer social interaction in computer-mediated simulation (live players interacting with virtual agents in a computer-generated simulation using, for example, avatars, virtual reality)
2) human-human interaction in live role-play simulation with live players interacting in face-to-face simulation (i.e., mannequin simulation)
3) human- social interaction in computer mediated simulation with live players interacting in a computer-generated simulation (i.e., avatars, 2nd Life, etc.), and
4) human-robot social interaction in live non-simulated settings.

We began the second portion of the review with a limited set of keywords (ethnomethodology, conversation analysis, simulations, interaction, dialogue, conversation, and debriefing), selected the literature that was most relevant to this project's simulation, and followed further citations using a "snowball" approach. Special attention was given to research that focused on teamwork training in medical and other professional environments and that analyzed social interaction among team members (for example, using video or audio recordings of naturalistic interaction, Stivers & Sidnell, 2016).

The third part of the review focuses on screen-based simulations. We focused on locating relevant research comparing screen-based and high fidelity simulations, and screen-based simulations teaching teamwork in medical settings.

Findings

Teamwork Dimensions for Team Training

Team training programs incorporate multiple dimensions of teamwork that are variously labeled, but cover similar constructs. For example, Salas et al. (2005) identified five core components of teamwork that should be included in training – team leadership, mutual performance monitoring, backup behavior, adaptability, and team orientation—along with a set of supporting coordinating mechanisms (shared mental models, closed-loop communication, mutual trust). Widely used team training programs cover much the same set of dimensions. The key dimensions underlying TeamSTEPPS (Team Strategies and Tools to Enhance Performance & Patient Safety, https://www.ahrq.gov/teamstepps/index.html), for example, are:

- team structure (e.g., assigning or identifying team members' roles and responsibilities)
- communication (e.g., using check-backs to verify information that is communicated)
- leadership (e.g., delegating tasks or assignments as appropriate; briefs/huddles/debriefs to create a shared understanding of/update/review the plan of action and its outcomes)
- situation monitoring (e.g., monitoring fellow team members to ensure safety and prevent errors)

- mutual support (e.g., provides timely and constructive feedback to team members) (Agency for Healthcare Research and Quality, 2006)

Some team training programs are tailored to the particular teamwork skills that are thought to be required in a specific domain or environment. For example, Reader (2017) describes how programs may highlight different decision-making skills depending on the demands of effective patient care in different scenarios: for example, leadership that fosters input from those in junior roles in cancer diagnosis teams vs. anticipating others' needs and supporting others in anesthesia teams.

Effectiveness of Team Training in Healthcare

Recent reviews show that healthcare team training is effective for a variety of outcomes, including trainees' perceptions of the usefulness of team training, acquisition of knowledge and skills, demonstration of trained knowledge and skills on the job, and patient and organizational outcomes (Hughes et al., 2016). Moreover, the meta-analytic review by Hughes et al. (2016) reported that a wide variety of moderators generally do not influence the effectiveness of team training, including:

a) the nature of training (e.g., information, demonstration, practice),
b) whether the training program provides feedback,
c) whether the training program uses simulators that are high on physical fidelity,
d) whether the team training is delivered to teams who are homogeneous in terms of profession or discipline
e) whether team training was provided to students or practicing clinicians, and
f) whether patient acuity (health status of the patient) was high or low.

One other moderator showed a counterintuitive relationship with outcomes: training that involved feedback exhibited weaker effects than training that did not involve feedback, at least for selected outcomes (e.g., learning of knowledge and skills). The authors note that the studies that included feedback were characterized by an authority differential between the giver (attending, senior staff) and receiver (junior staff, student) of the feedback and that feedback may have been aimed at the person rather than at the task, creating the possibility that anxiety decreased learning. Neither was the clarity of the feedback specified in the Hughes et al. (2016) meta-analysis. Clarity is a significant moderator of feedback effectiveness, as noted in a meta-analysis by Hysong (2009) that demonstrated a positive effect of audit and feedback effectiveness on patient outcomes. Effective feedback was clear, timely, specific, written, and frequent.

Measuring Acquisition of Teamwork Knowledge and Skills

A variety of methods have been used to measure acquisition of teamwork knowledge and skills, including questionnaires, surveys, observations, and interview. Very commonly, rating scales are used to judge teamwork dimensions, such as the 7-point communication rating scale used

by Healey et al. (2006) to measure team communication in interprofessional surgery teams (ranging from a high of 6 indicating that team communication was highly effective in enhancing teamwork to a low of 0 indicating that team communication severely hindered teamwork).

Effectiveness described or measured according to specific teamwork behaviors is less common. Most of these studies focus on leadership behaviors, such as the team leader introducing herself or himself, expressing what he or she is thinking, acknowledging vs. ignoring input from other team members (Bank et al., 2014), or the team leader actively seeking feedback, admitting when he or she does not know how to do something, taking notice of others' strengths, and showing appreciation for the unique contributions of others (Owens & Hekman, 2016). Some studies also include behaviors that apply to all team members, most notably communication skills such as relaying problems during attempts to execute technical tasks, or challenging others who are using inadequate or inappropriate therapy (Garden et al., 2010), or calling out the results of exams (Muller-Juge et al., 2014).

Even less often addressed is how teamwork behaviors might be incorporated into simulation-based training at the level of specific, observable behaviors. An exception is Rosen et al. (2008) who describe how simulations can be designed around critical events and the targeted responses that a team leader or team member should demonstrate in response to the event. For example, in the context of a scenario in which a patient suddenly collapses and becomes apneic and pulseless, and team members stand at the patient's bedside awaiting directions or orders, the team leader can demonstrate the leadership skill of observing and helping direct activities of other team members by asking the RN to put the patient on a cardiac monitor and then to secure an IV and asking the ED tech to begin chest compressions.

Impact of Teamwork Training on Teamwork Knowledge and Skills

In the many studies on the impact of teamwork training on teamwork knowledge and skills, the training programs cover all of the major dimensions of teamwork, without identifying any dimensions that should receive special focus or priority (for example, leadership vs. communication). Most studies find improvement in all of the major teamwork dimensions (e.g., team structure, leadership, situation monitoring, mutual support, communication, Sawyer et al., 2013; Weaver et al. 2010). There is some variation from study to study in which specific teamwork behaviors are improved by teamwork training, and no systematic pattern emerges about which skills are more (or less) amenable to change. Most studies report that training improves performance on most of the teamwork behaviors studied. The behaviors not showing improvement are quite varied across studies, such as existing teams orienting new members (Miller et al., 2012), or team members clarifying ambiguous orders, clearly identifying the leader, and the leader managing noise appropriately (Roberts et al., 2014). Despite evidence of short-term improvement in many skills following training, there are also indications of decay in many teamwork skills over time (several months to one year following training; see review by Weaver et al., 2014). Again, research reveals no systematic pattern in terms of which specific teamwork skills or behaviors are more (or less) resistant to relapse over the long term.

A review of team training in healthcare by Marlow et al. (2017) suggested future directions for healthcare team training in order to fill gaps in current understanding and improve training outcomes. Suggestions include: implementing team training in non-academic primary care settings; increasing the diversity of disciplines engaged; increasing the breadth of teamwork skills taught; distributing training over multiple sessions; using control groups in team training evaluations; expanding assessment measures to include observer reports, reporting systems, patient chart reviews, and automated performance reports; and evaluating the impact of training on patient care quality and clinical outcomes.

Teamwork Attributes that are Challenging to Represent in a Single Player Screen-based Healthcare Simulation

Several important teamwork skills described above present challenges to training via a single player screen based simulation, including addressing hierarchy/power distance in the instructor-learner relationship, managing stress/improving resilience, providing high quality feedback or debriefing, establishing trust/psychological safety, and promoting team cognition through creation of a team mental model and maintenance of team situation awareness.

While there has been significant study of the effects of hierarchy, status, and power on teams, these effects are quite difficult to represent via a single player screen based simulation. Status, the respect or admiration that an individual enjoys in the eyes of others, is a subjective hierarchical measure (Magee & Galinsky, 2008). It is known that high status individuals on a team motivate low status individuals, but can be uncooperative and reluctant to participate on teams in ways that would result in loss of status. Performance on collaborative tasks improves when both high and low status individuals are present on a team, but individual performance suffers when low status individuals must compete with high status individuals. Status and hierarchy disagreements can lead to poor team coordination, relationship conflict, and task conflict (Luan, Hu, & Xie, 2017). Because status is subjective, it is particularly challenging to represent in a single player screen based simulation; the player does not have the time or ability to develop interpersonal relationships and make assessments necessary to develop a status hierarchy.

Power is a non-subjective hierarchical measure, and is conferred by position or title. Power hierarchies are reproducible to some degree within a single player screen based simulation, because a strict hierarchy can be dictated by the game. Power hierarchies are more static than status hierarchies, and are more difficult to affect or change. Because of this, low-power individuals spend less time competing for high-power positions. However, because status requires positive estimations from peers, high *status* individuals are more likely to attend to others' opinions and perspectives and to treat others with fairness than are high *power* individuals (Galinsky, Magee, Inesi, & Gruenfeld, 2006). These interpersonal components of a power hierarchy will not be well represented in a single player screen based simulation.

Stress can significantly affect both team and individual performance. Team stress is defined as "the relationship between the team and its environment, including other team members, that is appraised as taxing or exceeding their resources and/or endangering their well-being" (Weaver, Bowers, & Salas, 2001). Team stressors include time pressure, task load, fatigue, role ambiguity, uncertainty, and many others (Driskell, J.E., Salas, & Johnston, 2006). Those participating on a team can also experience individual level stress. The combination of team and individual stressors reduce team performance effectiveness (Burke et al. 2008). Some of these stressors are challenging to reproduce in a single player simulation, but it will be possible for non-player characters to act as those who are stressed do--e.g. showing decreased cooperation and ineffective communication.

Team trust or psychological safety has been described as a key factor in team effectiveness (for a review, see Costa and Anderson, 2017). High trust in teams appears to lead to an increase in exchange of relevant information, and decreased conflict due to acceptance of the influence of teammates, and decreased efforts to control the behavior of teammates (ibid, 2017). Again, a single player screen based simulation does not afford the opportunity for the player to establish or participate in the creation of a climate of team trust with non-player characters. The simulation may be able to approach skill development in this area by rewarding the player for eliciting information from non-player characters.

Perhaps the highest order team skills are those of team cognition: creating and sustaining a team mental model and team situational awareness. A meta-analysis by DeChurch & Mesmer-Magnus (2010) examined team cognition in relation to team behavioral process, motivational states, and team performance and found a strong positive association. Because the skills of team cognition exist at a group level, a single player game would not afford training or practice of these skills. In the future, creation of a multi-player screen-based simulation may provide an opportunity to explore this important parameter of teamwork.

Methods of Simulation-based Teamwork Training: Observational (Vicarious) vs. Participatory Learning

Training using teamwork simulations can involve learners as participants or as observers (or both). Research investigating these two modes of learning from simulations in healthcare settings generally finds that observing teamwork simulations produces gains in knowledge, skills, attitudes, and behaviors regarding technical and nontechnical skills, and, under some circumstances, may be more effective than participating in simulations alone. For example, in a review of nine studies that compared participating in healthcare simulations versus observing simulations for a range of outcomes, O'Regan et al. (2016) found that playing an observer role was as good as, or better than, carrying out a hands-on role in simulations. The benefits of observation were especially pronounced in studies that used tools that encouraged "active" observing rather than passive watching. Research has also documented advantages of observational learning for knowledge of doctor-patient communication skills, and confidence in being able to overcome hierarchy-related issues to resolve disagreements in the team setting,

especially when observations are supported by an explicit observation script (Stegmann et al., 2012; McEwen-Campbell, 2015).

Design Issues Related to Authenticity of Screen-based Simulations

Research shows that lack of perceived authenticity in simulated scenarios restricts validity of participants' behavior only when players notice deviations in the settings, dialogue, or events in the simulations that they cannot make sense of or appear arbitrarily motivated by the game designers or whenever they see their actions as 'unfairly' assessed (Stokoe, 2011; 2013; 2014). In simulation game settings, participants can generally accept artificiality in their or non-player characters' actions as long as the actions and events in the game retain their applicability to real-life settings (De la Croix & Skelton, 2009). Players can readily accept limitations of the medium (e.g., low-resolution graphics, keyboard text-based input) and constructed elements of the simulation (e.g., storyboard elements, toolbars, etc.) so long as these are provided in an organic, accountable, and—for the player—predictable manner. What appears central to the players' sense of efficacy is their ability to reliably build repeatable actions in that environment even if they are not entirely life-like in execution (Spagnolli, Varotto, & Mantovani, 2003).

The degree to which human participants are likely to treat their virtual-agent interlocutor as a conversational agent depends on the responsiveness of the virtual agent (Corti & Gillespie, 2016; Fischer & Batliner, 2000; Fischer, 2011; Hudlicka et al., 2009; Fischer et al., 2013; Fischer & Kerstin, 2011), and the expressive features of communication like social cues or more general features of prosocial interaction (e.g., "believability," "reciprocity," "reflexivity"). A number of researchers raise cautions against ignoring the ecological validity of the conversational actions and behaviors that they script for the player and non-player characters: simulations that do not adequately anticipate what is routine for a given setting may provide little to no guidance in later informing participants' behavior in the target setting (Husebø et al., 2012; Stokoe, 2013; Sjöberg, 2014; White & Casey, 2016). For example, one reason why medical learners do not always benefit from practicing consultations with simulated patients (Lane & Rollnick, 2007; Lane, Hood, & Rollnick, 2008) may be divergence of simulated interactions from their real-life counterparts. De la Croix and Skelton (2009) found that simulated patients (SPs) in simulated doctor-patient conversations sometimes presented a poor model of how patients might behave; SPs were more dominant and assertive (e.g., asked more direct questions, more likely to initiate topics) than real patients. Recordings of real-life encounters may help inform the design of interactions, composition of talk, and actions produced in simulated settings (Stokoe, 2013).

Feedback and Debriefing in Simulated Teamwork Settings

As noted above, the effectiveness of feedback (provision of information) in team training is mixed and may depend on the quality of the feedback and specific circumstances surrounding

the feedback conversation. A screen based simulation can be programmed to provide feedback that is clear, immediate, written, and specific to the error(s) noted.

It is more challenging to incorporate debriefing – facilitated back-and-forth discussion of prior performance, usually involving an instructor or other expert – into an automatic simulation. Debriefing with human facilitators has been found to play an important role in students' acquisition of knowledge (Crookall, 2010; Husebø et al., 2012) due to the opportunities for learners' reflection on their performance and thinking, connections the facilitator makes between the learner's performance and the learning objectives of the simulation, the facilitator's guidance of the learner toward certain ends, and the facilitator's alerts about how the real-life situation may differ from the simulation (Schick, 2008; Seale et al., 2007).

In the absence of a physically or virtually co-present facilitator, instructor, or tutor, a simulation can incorporate "self-debriefing" (Walther, 2013). Effective self-debriefing consists of non-ambiguous automatic prompts that encourage players to actively reflect on their performance and make connections to real-world settings. A simulation can be punctuated by multiple debriefings with game play occurring between the debriefings. For valid and effective debriefing, lessons learned in prior game-play or in the debriefing are effective in later game-play (van den Hoogen, Lo, & Meijer, 2014). One way of promoting the internal validity of the simulation and debriefing as a whole process is via event-structure analysis (ibid, p. 3509). This method analyzes causality within the game specifically as a sequencing of events that have a specific temporal ordering, where past actions/events constrain future actions/events, or, through temporal side branches, indirectly trigger later actions/events. "Narratives" for the player and/or facilitators are specifically built from these events for digest and use in the debriefing. Counterfactuals play an important role in this regard. Every event is analyzed as if it were just an instantiation of another possible event that is the negation or modification of that specific event, basically requiring that the participants entertain "what if-questions" (ibid).

Screen-Based Simulations Versus High Fidelity Simulators

Some researchers have found that use of screen-based simulations elicited better performance than those of a control group, e.g., when learning cardiac arrest procedures (Bonnetain, Boucheix, Hamet, & Freysz, 2010). Screen-based simulation has also been shown to be as good as high-fidelity simulators in anesthesia training (Nyssen, Larbuisson, Janssens, Pendeville, & Mayné, 2002; Schwid, Rooke, Michalowski, & Ross, 2001). The latter study also showed transfer between the screen-based to mannequin-based simulators, but did not show transfer to real-life situations.

Screen-Based Simulations Teaching Teamwork in Medical Settings

One of the programs we reviewed was the Safe Surgery Trainer, a screen-based simulation teaching teamwork skills in the operating room (Murphy, 2014). Research using this software (Kreutzer, Marks, Bowers, & Murphy, Curtiss, 2016, p. 49) demonstrated that:

Participants who played the game demonstrated higher levels of declarative knowledge about effective communication behaviors. Those who played the game were also better able to apply knowledge about effective team communication to novel situations, and displayed higher levels of training transfer in comparison to those who took the knowledge test first. Thus, playing the game was indeed helpful. This suggests that in addition to increased knowledge, behavioral changes are possible if a game delivers appropriate information and provides opportunities for practice.

Our review also included the aspects of the interface and interactivity that could be emulated or enhanced. Having the player take on multiple roles to see different perspective across the team was considered beneficial. We also liked the reduced focus on the medical aspects of the tasks and greater emphasis on the teamwork skills. We felt that the communication dialog boxes could be enhanced by providing more open-ended forms of communication (typed and/or spoken).

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Appendix A

An initial search in PubMed, CINAHL, ERIC, and PsycINFO, and Business Source Premier was completed. Separate searches on Simulation & Team Training and Transferability of feedback to team function were conducted and duplicates were excluded. Search terms are detailed below for each database.

Methods in Simulation & Team Training
PubMed strategy: ("Patient Care Team"[Mesh] OR "team training"[tiab] OR teamstepps[tiab] OR "team stepps"[tiab]) AND ("Computer Simulation"[Mesh] OR "Virtual Reality Exposure Therapy"[Mesh] OR "Computer-Assisted Instruction"[Mesh] OR "Video Games"[Mesh] OR "virtual reality"[tiab] OR "Computer gaming"[tiab] OR "augmented reality"[tiab] OR simulation[tiab] OR "screen-based"[tiab]) AND ("methods"[Subheading] OR "Methods"[Mesh] OR "Computing Methodologies"[Mesh] OR method*[tiab])
Number of unique citations (total citations minus the transferability & overlap) retrieved on 9/28/16: 520
CINAHL strategy: ((MH "Multidisciplinary Care Team+") OR TX ("team training" OR teamstepps OR "team stepps")) AND ((MH "Computer Simulation+") OR (MH "Virtual Reality") OR (MH "Computer Assisted Instruction") OR (MH "Video Games+") OR (MH "Simulations+") OR TX ("virtual reality" OR "Computer gaming" OR "augmented reality" OR simulation OR "screen-based")) AND ((MH "Data Collection Methods+") OR (MH "Computing Methodologies+") OR TX method*)
Number of unique citations (total citations minus the transferability & overlap) removing PubMed duplicates: 388 (416 before removal of duplicates)

ERIC: (DE "Team Training" OR TX ("patient care team" OR "team training" OR "teamstepps" OR "team stepps")) AND (DE "Computer Simulation" OR DE "Computer Assisted Instruction" OR DE "Computer Games" OR TX ("virtual reality" OR "Computer gaming" OR "augmented reality" OR simulation OR "screen-based")) AND ((DE "Methods") OR (DE "Training Methods") OR TX method*)
Number of unique citations (total citations minus the transferability overlap) removing PubMed duplicates: 20 (21 before removal of duplicates)

PsycINFO: (SU.EXACT.EXPLODE("Teams") OR ("patient care team" OR "team training" OR teamstepps OR "team stepps")) AND ((SU.EXACT.EXPLODE("Simulation") OR SU.EXACT.EXPLODE("Computer Assisted Instruction") OR SU.EXACT("Virtual Reality") OR SU.EXACT.EXPLODE("Computer Games")) OR ("virtual reality" OR "Computer gaming" OR "augmented reality" OR simulation OR "screen-based")) AND (SU.EXACT.EXPLODE("Methodology") AND method*)
Number of unique citations (total citations minus the transferability & overlap) removing PubMed duplicates: 14 (14 before removal of duplicates)

Business Source Premier: ((DE "TEAMS in the workplace" OR DE "CROSS-functional teams" OR DE "MULTINATIONAL work teams" OR DE "SELF-directed work teams" OR DE "SENIOR leadership teams" OR DE "TASK forces" OR DE "VIRTUAL work teams") OR TX ("patient care team" OR "team training" OR teamstepps OR "team stepps")) AND (DE "SIMULATION methods & models" OR TX ("virtual reality" OR "Computer gaming" OR "augmented reality" OR simulation OR "screen-based")) AND (TX method*)
Search limited to scholarly articles
Number of unique citations (total citations minus the transferability & overlap) removing PubMed duplicates: 192 (193 before removal of duplicates)

Total citations count minus the transferability & overlap before removal of duplicates: 1164
Total citations count minus the transferability & overlap after removal of duplicates: 1134

Subject Matter Expert Interview Summary

I. Where is teamwork crucial?

- Several interviewees stated that teamwork was crucial for high-acuity medical situations. In trauma for instance (Amodeo), the fast-pace setting, number of people involved, and number of disciplines involved makes determining the leader difficult. It requires an understanding of the patient before coming to trauma, who should be involved, who will lead and what leadership role should entail. Advocated for leader to be hands off, have more situational awareness (Amodeo).
- Such situations highlighted the need for having individuals monitor the bigger picture outside of the patient (i.e., how many cases are coming in and how that affects the team members caring for the current patient). People must also share mental model as to how participants identify as leader (Hund). Communication is crucial in making sure what vitals are, what equipment and tests are needed-all in very short timeframe. Baker puts emphasis on participants shared mental model for roles and expectations.
- Gaba gave one concrete example: The patient was in the lateral position with double lumen tube with ongoing surgery. The surgeon offered if better to finish and flip patient. The surgeon basically gave permission for something ANES should be requesting, which was both helpful and perceptive.

II. What are important skills for high acuity settings

- Hund: The top three are 1) situational awareness and monitoring what's going around you. Need to understand what you're doing but also what's happening around you and what others are doing that might affect what you do (cascading affect). 2) Ability to challenge hierarchy and status quo thinking (i.e. CUS. 3), skills around leadership: briefing and debriefing, what/how we can do things differently next time.
- Baker on the other hand stated that while many might say communication is the most important skill, but in actuality, participants' ability to define

roles, have check-ins and markers, and have common goals are much more important. Gaba also emphasized the importance of distribution of work, role clarity, knowing when to call for help, how to designate leadership. He also named role clarity as important.Holcomb also emphasized the role of consistency in teamwork and felt that expertise was sufficient for teamwork

III. What undermines teamwork?

- Lack of preparedness; undermining trust in one or others' ability to fulfill roles in organization (Hund).
- Gaba considered hierarchy, cultural issues (domain/disciplinary tribe, physicians, nurses, others; production pressure and how that affects individual and team; institutional culture – system created incentives or disincentives to work in a certain way; national culture)

IV. Traits and practices for good team-player:

- Hund stated that being a good listener, open to critique, and ability to adapt important traits. Holcomb argued that while technical skills were the easiest to teach, assimilating data and decision-making was harder. At the same time, however, Holcomb suggested that expertise and proficiency were sufficient for effective teamwork suggesting that while teamwork skills are important, they are the outcome of an experienced, proficient professional.
- Traits and practices for poor team-player: not wanting to change, bad listener, feel that others don’t have same knowledge as they do

V. Challenges to Teaching Teamwork:

- 1) Must be taught through experience and experiential learning. Hardest skill to teach is situational awareness and how to recognize need for mutual support (Amodeo & Hund)
- 2) Teamwork seems to be an easy concept to grasp; people think they know what teamwork looks like, but that is not always the case. 2) The skills being taught are really common sense. The learner already knows

so many tools and strategies, and that's very helpful, but teaching them how to implement is the trickier part. They need to identify that there is a teamwork problem, understand how to implement an intervention, and assess the effectiveness of intervention. Problems with "compliance of a bundle" (Amodeo). Baker similarly commented that the problem with teaching teamwork is that you aren't teaching anything new to participants; they may learn or know "SBAR" tool but what's important is teaching them how and when to implement the tool in a sustainable manner.

VI. What skills are easiest to teach?

- Communication is easiest because most people think that is the root problem so they are highly motivated to learn communication tools. Baker: The knowledge part is easy, the application part is the hard part. Communication tools are the easiest to teach. Assertiveness tools are harder to teach to people who are not in leadership role.

VII. What skills are difficult to teach?

- Getting practitioners to separate medical practices and procedures from teamwork--uses games and activities that have nothing to do with medical setting so learners can focus on teamwork skills. Similarly, when we use simulation we find that it's helpful to assign individuals roles not consistent with their expertise or "day job" in effort to try to get them to focus on teamwork aspect vs clinical aspect. In simulated activities, pre-assigning individuals roles frees learners from having to know what their roles are in the simulation is, allowing them to focus on teamwork for feedback.

VIII. Ad-hoc vs. standing teams:

- There was a lot of consensus on this issue. Good idea to have both but each has particular demands: With standing teams, we teach learners to take whatever teamwork skill they are using and make it their own. With ad-hoc teams who have different people with different toolkits, they depend on having the same language and same set of expectations when

coming into a situation. Hund: Both are important but ad-hoc teams are harder to train for. Hund also puts emphasis on

IX. Advantages of TeamSTEPPS:

- Amodeo stated that it is evidence-based, so many skills and strategies are already familiar to learners. Familiarity really helps. You don't have to teach every possible strategy or tool, you can tailor it to their workplace/environment so it's not overwhelming. You just give them a bit of resources to make their work more effective. Hund points out that TeamSTEPPS fits with medical training because it was developed explicitly for healthcare situations with a focus on clinical situations. Baker also points out that TeamSTEPPS has brand recognition, and thus a easier grasp as to why it's important.

X. Pitfalls of TeamSTEPPS:

- One notable pitfall for TeamSTEPPS mentioned by Hund is that there's not enough specificity: Lacking in giving tools for situation monitoring. It just says be aware of your surroundings. There are so many tools and strategies in the curriculum, its hard to coach individuals on the scope side and find the right tools to address and remedy their problem. Also, there is a misperception that TeamSTEPPS is a "cure all." Helping individuals know difference between what a teamwork issue is versus what's a personality issue or an organizational barrier-that's a challenge. Sustainment is a challenge and that's not specific to TeamSTEPPS. People need opportunity to practice tools and use them and opportunity to know they are doing them well. Also be able to see benefits in a transparent way (e.g., reduced infection rate or time to intubate has decreased).

XI. Tools for teaching:

- Hund states that mixed-methods approach works best in teaching. More important is in designing games that help people think about teamwork in ways that that are not healthcare specific. If entirely clinical they get easily distracted by medical management, so by having games not clinically

related they can focus on teamwork skills. So in designing game, it's important to make sure not to allow players to get distracted by medical aspects and instead focus on teamwork aspects

- Gaba argues for focusing on in person training, mostly resident level and above, not novice learners. Roles may be played by confederates, or experienced professionals in their own roles. Use ancillary techniques, such as trigger videos or game-like activities.

XII. Military Implications

- People with military backgrounds have different view of each other in clinical settings, view of what debriefing means, their approach is different, we like conversation and nuances, they tend to more cut and dry with objectives (evolution, hogwash) so a lot of plus delta format, feedback sandwiches, more rigid because of nature of how training is done in their setting. Stick to learning objectives and may miss forest to the trees. Look at how hierarchal and collegial, rules and entrepreneurial thresholds. VA has higher hierarchy because a lot of ex-military on administration and among clinicians, inherit structure from military.
- Military has more standardization; less likely for teams to customize how they work--more structured. People with certain titles will have certain roles; problems with speaking up because of hierarchy; ranges in age and general experience in professional settings quite broad affecting performance.

XIII. Goals/Teaching Objectives: Wide variety on responses; see primary interviews

XIV. Feedback: Wide variety on responses; see primary interviews

Focus Group Summary

In addition to a literature review and subject matter expert interviews, focus groups of healthcare professionals with experience in teamwork were conducted by Rachel Lewin (primary interviewer) and Maria Rudolph (secondary interviewer and recorder). Focus group participants were recruited by email from UCLA Ronald Reagan Medical Center. Ten healthcare professionals participated in four focus groups composed of physicians, nurses, and respiratory therapists, all with experience in acute care services. One participant now works in quality improvement.

Focus group participants were asked to be frank in their observations. They were informed that the focus group discussion would be used to inform the development of the screen-based simulation. The focus groups were conducted under an agreement of confidentiality: participants agreed not to share the content of the discussion outside of the group and interviewers assured the participants that both their participation and their responses would be de-identified in all verbal and written reports. Focus groups were videotaped for later reference by the interviewers only.

Focus group questions can be found in **Appendix A**. Focus group interviews were semi-structured to allow for exploration of emerging themes. Subsequent to the interviews, participants were asked to rank a list of teamwork actions in order of importance (**Appendix B**). Four participants returned their rankings.

All focus groups lasted for one hour. Participants spoke with intensity and emotion. Their desire for good teamwork, their dedication to their work, and their loyalty to their patients was evident in their engagement with the topic.

The most prominent themes voiced by focus group participants were:

- ➢ INTRODUCTIONS
- ➢ ROLES/TEAM STRUCTURE
- ➢ COMPOSURE
- ➢ VISUAL CUES
- ➢ BRIEF/HUDDLE/TIMEOUT/DEBRIEF
- ➢ PSYCHOLOGICAL SAFETY
- ➢ MUTUAL SUPPORT
- ➢ NORMS & COURTESY
- ➢ CLEAR COMMUNICATION
- ➢ DESIRE FOR PREVIOUSLY DEFINED SHARED MODELS
- ➢ CONSIDERATION OF DUAL LEADERSHIP DURING CRITICAL INCIDENTS

INTRODUCTIONS

Introductions were universally seen as critically important to teamwork by the focus group participants, voicing strong opinions such as, “The worst crime is not to introduce yourself.” “You wouldn’t go into someone’s house and not introduce yourself.” On acute care services such as

the Pediatric ICU or in emergencies such as Code Blue, it frequently happens that the team members taking care of a patient in crisis may not know each other. Two types of introductions were emphasized: participants felt that it was important for arriving team members and for those already present to introduce themselves to each other, e.g., “I’m from [role], I’m [name]. Who’s in charge? Who’s the nurse in charge?” and “I’m [name], the [role]. Who are you/where are you from?”

ROLES/TEAM STRUCTURE

Clarity of roles and team structure were also emphasized. Participants felt it was important to know each team member’s role. Establishing roles may overlap with introductions, e.g., “Hi, I’m [name], here to relieve [name or role].” If the team leader has not been identified, it is appropriate to ask, e.g., “Who is team captain?” They appreciate visual cues such as uniform color to make it easy to identify the discipline of each team member. If there is more than one person from a given discipline present, e.g., two respiratory therapists (RT), it is important to assign a specific function to each RT. If possible, they like to have roles assigned prior to the event. Participants bemoaned lack of team structure. Participants also decried poor team structure. One participant described the consequences of losing a team structure that had been working perfectly due to new hospital management. The new structure resulted in overlapping roles, creating confusion and conflict.

COMPOSURE

Participants spoke frequently about composure, particularly in the team leader (“The way you lead the code sets the tone.”) A successful leader is able to “keep their cool” and is not responsive to negativity.“ If the team leader loses their sangfroid it can result in poor team coordination and effectiveness due to loss of trust in the leader. Deliveries always go better “when you have calm people, not fumbling. If the leader is anxious or loud, things fall apart.” One participant said that it may even be necessary to remove someone from leadership if they become agitated.

VISUAL CUES

Participants appreciate nonverbal cues that assist in communication of roles and process. In addition to the uniform denoting the team members discipline, participants cited use of hats, colored stethoscopes, or colored vests to identify roles. Participants also discussed position around the patient, e.g., a team leader standing at the foot of the bed or at the level of the patient’s groin so that the femoral pulse can be monitored throughout a trauma resuscitation. Participants also noted the importance of eye contact, particularly when team members work together frequently: “Sometimes we don’t say anything but it is flawless.”

BRIEF/HUDDLE/TIMEOUT/DEBRIEF

Participants noted the importance of shared communication during briefs, huddles, timeouts, and debriefings. These moments provide opportunities for role clarification, making sure that all necessary personnel and equipment are present, and creating a shared understanding of the patient’s condition and plan of care: “It’s very helpful to start with an open, inclusive timeout;” “You’re ahead of the game if you can have a plan;” “It helps if you have a huddle. If you know

your job and your role everything goes more smoothly. It helps if you know people. When it flows like that it becomes very much about the patient;" "A huddle is very important part way through a code. You can say what has happened so far, ask for corrections, and ask everyone if they have any other suggestions." Participants also expressed a desire for more time to debrief following stressful or difficult incidents.

PSYCHOLOGICAL SAFETY

Participants placed high value on a climate of psychological safety in teams. In particular, they felt that the team leader should be open; encourage speaking up; elicit and appreciate feedback; be courteous; be respectful. Participants suggested language such as, "Does anyone have any other thoughts or suggestions?" "I know this is difficult, but please tell me what I can do to help you;" "(during surgery) Does anyone have any concerns? Any thoughts before closure?" "As a leader, I feel it's important to support you." Leaders can promote psychological safety by "taking time to let everyone introduce themselves; be approachable; open the floor to questions, concerns." "The hero of my day is the person who is very inviting and open to suggestions." Participants made additional statements such as, "You have to let people know they are on a team;" "Don't point fingers;" "Building rapport and credibility are personally important;" "Attitude makes it easier to speak up. If the person is judgmental, it's harder to speak up;" "Empower the rest of the staff;" "Try to realize everyone is doing the best they can-- even the most seasoned people can be off-- be willing to accept feedback. An attending who micromanages affects the outcome;" "If you don't have support, direction, and guidance from top management, you won't care. You have to have buy-in."

One participant related an anecdote demonstrating the importance of psychological safety in the operating room: A surgical technician noticed something amiss. If she had been with a peer she would have spoken up but because she was only with physicians she was afraid to speak up. As a consequence, the patient had to go back to the operating room for a second procedure because she had not spoken up. Upon review, one physician said it was her duty to speak up. Another physician objected, asking, "don't we have a hierarchy?"

MUTUAL SUPPORT

Participants stressed the importance of team members supporting each other and being aware of one another's performance: "There is never a time when you are working by yourself. You are always on a team;" "A team is only as strong as its weakest link;" "Give concrete feedback, for example, slow down/speed up compressions to a rate of 100/minute;" "One-on-one mentoring is most important-- mimicking, modeling, asking for feedback;" "The best outcomes are when roles overlap-- then you can be prepared to offer mutual support." Lack of mutual support was cited as a major problem: "Before, we had the team/friend approach-- we had each other's back-- we didn't have to agree but we could discuss without fear."

NORMS & COURTESY

Participants felt that it is important to identify, practice, and reinforce norms and interact with courtesy: "It should be uncomplicated;" "I would like to have a sign in front of the room that says,

‘please introduce yourself;’” it helps if people are friendly and “introduce themselves with, ‘Good morning, I’m….’”

CLEAR COMMUNICATION

Participants gave many examples of the importance of clear communication, including sharing thoughts and narrating actions. A respiratory therapist said that he might say, for example: “If I need to bag mask, I’ll be rotating to the head of the bed,” in order to let the rest of the team know what he is thinking and what future actions he may take. Communication helps to create shared mental models between disciplines: “Nurses can be very tracked on their goals;” problems can be remedied by “giving feedback, talking out loud, stating actions, reporting what you can see, for example, ‘I see chest rise.’” Communication facilitates teamwork and builds rapport: “You have to describe what you need from your team members. Be clear, respectful, professional.” Communication is used for clarification: “You have to have a sense of what you are supposed to do, what is expected of you.” In an emergency, “the situation is always very fluid. You need to stay on top of the situation. You need open communication so that you can adjust the plan.” “The sicker the patient, the more important the communication.”

DESIRE FOR PREVIOUSLY DEFINED SHARED MODELS

Participants evinced a desire for previously defined shared models, for example, algorithms and protocols for patient management; an established understanding of what roles are needed in certain circumstances; an understanding of how other disciplines divide tasks and define roles; a shared culture; and a shared vocabulary. Using resuscitation algorithms or scripted moves is seen as promoting success during a code. Simulation is appreciated as a way to practice performance during critical incidents. Teams need “agreement on crossover/territorial issues to establish boundaries and they need clarity to resolve differences between conceptions of roles.” When previous agreement on roles is absent, “resolving problems with roles takes a long time. People get threatened--defensive and angry.” For example, at one point a trauma activation protocol was revised and now there is unclear communication and role confusion, leading to dysfunction and anger between services. TeamSTEPPS was considered helpful because it taught a common teamwork curriculum to everybody. The Neonatal Resuscitation Program teaches situation awareness effectively.

CONSIDERATION OF DUAL LEADERSHIP DURING CRITICAL INCIDENTS

Participants felt that the code or trauma leader “should not be ambiguous;” “When the team captain is called out it makes a huge difference.” Participants were not unified on whether there should be a single leader or a code/trauma leader (usually a physician) and also an event manager (usually the charge nurse). “The most chaotic situations are on adult floors-- pediatrics floors have a rapid response team that is well trained. Nurses have training. Nurses should direct everything-- if people leave who know the patient the nurse needs to be empowered to say that this is her patient, and give history. The only problem with “putting on the vest” [taking leadership] is-- does that mean that person will remain leader no matter what?”

Appendix A

Focus group briefing:

1. Interviewer introductions.
2. Brief participant intros (just names, field).
3. Review purpose/objectives of focus group.
4. Explain roles (RL main facilitator, MR note-taker).
5. Set ground rules.
    a. Confidentiality (we will not share).
    b. Confidentiality (ask them not to share).
    c. Nothing at stake.
6. Request permission to videotape.
7. Make sure everyone comfortable, has lunch, knows where to wash hands, etc.
8. Begin session with expanded introductions (occupations, roles, experience levels, types of teams they are on).

Focus group questions:

"We're looking for specific suggestions about the kind of language that is most effective in teamwork situations"

Tell me about a time when you were on a team and communication and teamwork were excellent.

- What was your role on the team?
- How do you introduce yourself? What would you consider an ideal introduction?
- What specifically made you feel the teamwork was excellent?
- What position did the team leader hold?
- What did they do that made it clear they were the leader? What did they say that would make this clear?
- How did they facilitate communication?
- If it was ambiguous who was in charge, how was a leader determined?
- When has leadership needed to change mid-situation, how has this change in leadership happened? What made it clear that the leader was changing?
- Were other people integral to the team's success? If so, how?

Tell me about a time when you were on a team and communication and teamwork were poor.

- What was your role on the team?
- What specifically made you feel the teamwork was poor?
- Was there a clear team leader? If so, what position did they hold? How did they facilitate communication?
- What makes you feel safe speaking up on a team? How have you seen people encourage or stifle feedback?

Have you received any training in teamwork?

- What kind of training?
- What part or parts of this training did you find most helpful and why? Least helpful and why?
- In what ways was this training helpful in a clinical setting?

Have you ever taught teamwork?

- What skills do you find easy to teach?
- What skills do you find hard to teach?

What is important about teams and teamwork that hasn't come up here?

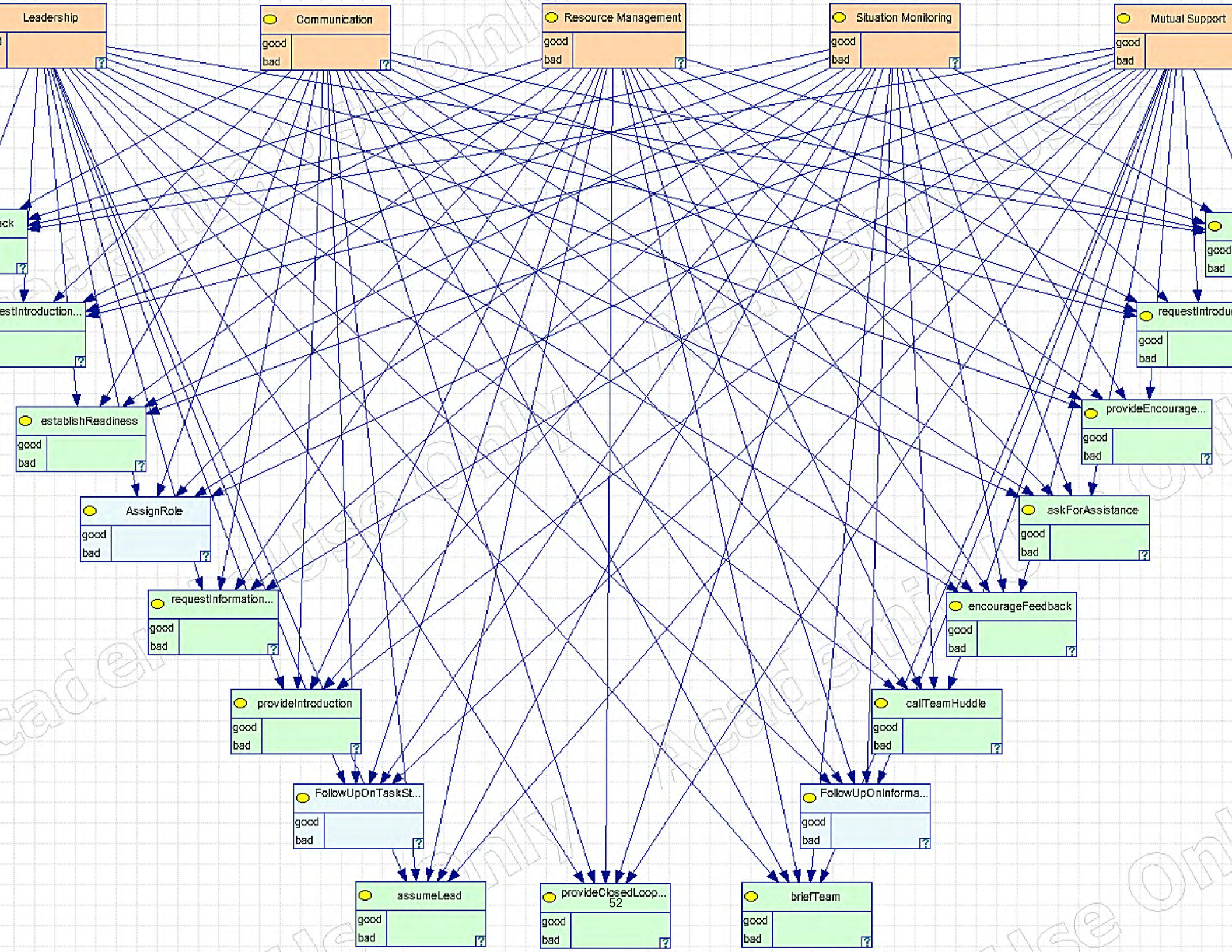
Appendix B

It would help us very much to know **how you, based on your experience, would RANK these actions, in order of importance**:

Team leader or member…

- _ **introduces him/herself**
- _ **makes their role clear**
- _ **asks team member(s) for information**
- _ **follows up on incomplete information**
- _ **assigns tasks to team member(s)**
- _ **follows up on incomplete tasks (e.g., by reassigning tasks, doing tasks him/herself, or taking other corrective action)**
- _ **performs task that has been assigned to him/her**
- _ **performs task on own initiative (e.g., sees that nobody was assigned to do a needed task, thus performs task him/herself)**
- _ **briefs team members (e.g., with input of team members, assesses situation and makes a plan)**
- _ **huddles with team members (e.g., initiates information sharing with team members and adapts plan if necessary)**
- _ **debriefs team members (e.g., After Action Review: discusses what went well and what could be improved)**
- _ **changes his/her position in room (e.g., to perform a task, to have a better vantage point, to make room for other team members, etc.)**
- _ **answers questions from team members**
- _ **objects (speaks up) to other team members (e.g., to prevent a possible mistake)**
- _ **requests help from other team members**
- _ **provides help to other team members**
- _ **gives feedback to other team member(s) (e.g., "well done!", "next time, please make sure you look at the monitor when doing ...")**
- _ **elicits feedback from team members (e.g., "if you see something that isn't right, please speak up")**

If you would send your rankings as a reply to this email, we would greatly appreciate it. Please put a “1” by the MOST important action, a “2” by the next most important action, and so forth. We will collate the responses and use them to guide us as we develop our simulation. Please let us know if you have any questions.


Leadership
Communication
good
bad
Resource Management
good
bad
Situation Monitoring
good
bad
Mutual Support
good
bad
establishReadiness
good
bad
AssignRole
good
bad
requestInformation...
good
bad
provideIntroduction
good
bad
FollowUpOnTaskSt...
good
bad
assumeLead
good
bad
provideClosedLoop...
52
good
bad
briefTeam
good
bad
FollowUpOnInforma...
good
bad
callTeamHuddle
good
bad
encourageFeedback
good
bad
askForAssistance
good
bad
provideEncourage...
good
bad

Design of a Screen-Based Simulation for Training and Automated Assessment of Teamwork Skills

Software Specification

Version 6.0

Award Number: W81XWH-16-1-0308

Prepared by CRESST/UCLA

last updated: July 31, 2018

1. Introduction

The purpose of this document is to provide the software specifications for the screen-based simulation software for measuring and teaching teamwork skills. This document also uses an agile methodology and is therefore a living document that will have multiple iterations. Some sections will be more detailed than others.

The software consists of two modes that present scenarios and instruction/feedback to elicit actions from the user. The two modes are:

1) Gameplay mode: This mode is interactive, allowing the users to take actions. If a player action is expected and the player does not do anything, after a designated amount of time (timeout 1) a stimulus is presented. If the player still does nothing, after some defined time (timeout 2), an NPC or intervening dialogue box will move the scenario forward.
2) Evaluative mode: This mode plays back the same scenarios from the gameplay mode and pauses at defined time instances for the player to answer questions (multiple choice, MC) about what was good or bad with respect to teamwork skills in the just presented game play.

1.1. Summary

This software is to be used in the research proposed by UCLA Medical School Simulation Center, UCLA Graduate School of Education and Information Sciences, and the UCLA Center for Research on Evaluation, Standards, and Student Testing. This effort is funded by the Department of Defense through JPC-1. The PI is Dr. Randolph Steadman.

1.2. Requirements

The requirements for the software include the ability to capture player input (actions in the gameplay mode, or MC answers in the evaluative mode), and to assess a participant's knowledge, skills, and attributes (KSAs) related to teamwork skills in medical settings. The software will also provide feedback/instruction between each scenario (called the AAR or after-action review) and will consist of 3 scenarios of relatively equal difficulty but in different settings: ER, OR, and ICU. The primary goal is to assess and teach teamwork skills in medical settings like the emergency department, operating room and intensive care unit.

1.3. Numbers

The number of users expected to use the system are in the low hundreds, and to be able to be done over the internet from home. The users are expected to be primarily physicians and nurses.

1.4. Terminology

PC: Player Character (always the leader)

NPC: Non-Player Character (other team members)

2. Functional Description

Tutorials (one for each mode)
This tutorial is for familiarizing the user with the game interface with opportunities to practice interacting with the game/simulation. Participants must complete the tutorial successfully to continue on to the other scenarios.

The tutorial will go through:

1. What the different parts of the interface are and give the player an opportunity to tryout different game mechanics themselves.
2. How to perform actions
    a. Gameplay mode:
        i. How to move (i.e., change the view) in the 3D environment (3 hotspots: foot of bed, head of bed, side of bed)
        ii. How to delegate tasks to NPCs
        iii. How to perform actions and explain the function of action buttons: select NPC or TEAM, then select action button that then explains the button's function
        iv. How to communicate (dialogue selection)
        v. How to pause game (using Tab key)
        vi. Explain what this game is about: goals of the game, who you are (leader), what you are supposed to do (lead)
        vii. Navigating to and using After Action Review (AAR)
        viii. Navigating to the next scenario

b. Evaluative mode:
    i. How to play back scenarios
    ii. How to provide answers to questions (multiple choice)
    iii. Explain what this mode is about: goals of the evaluation, what you are supposed to do (evaluate team leader performance)
    iv. How to navigate and use the AAR
    v. Navigating to the next scenario

Gameplay Mode

Gameplay mode can be paused at any time. The interface for the gameplay mode should look something like the following (Figure 1):

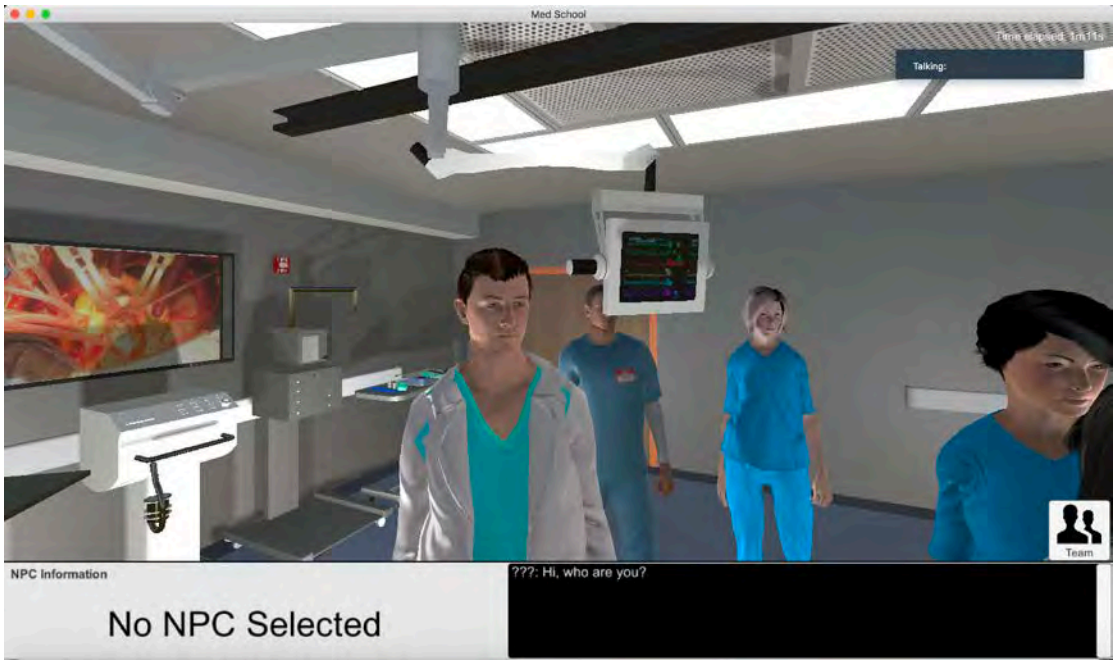


Figure 1. Game Play Mode Interface

UI Elements

Game Window: The main portion of the screen is the 3D game environment.

Modes: NPC, TEAM

Information window: Provides status of Team Leader's awareness of others and what they are doing

In gameplay mode, the scenario should move forward even if the Player Character (PC) does nothing. One or more NPC's can intervene and either do or suggest the next medical action.

Additional requirements:

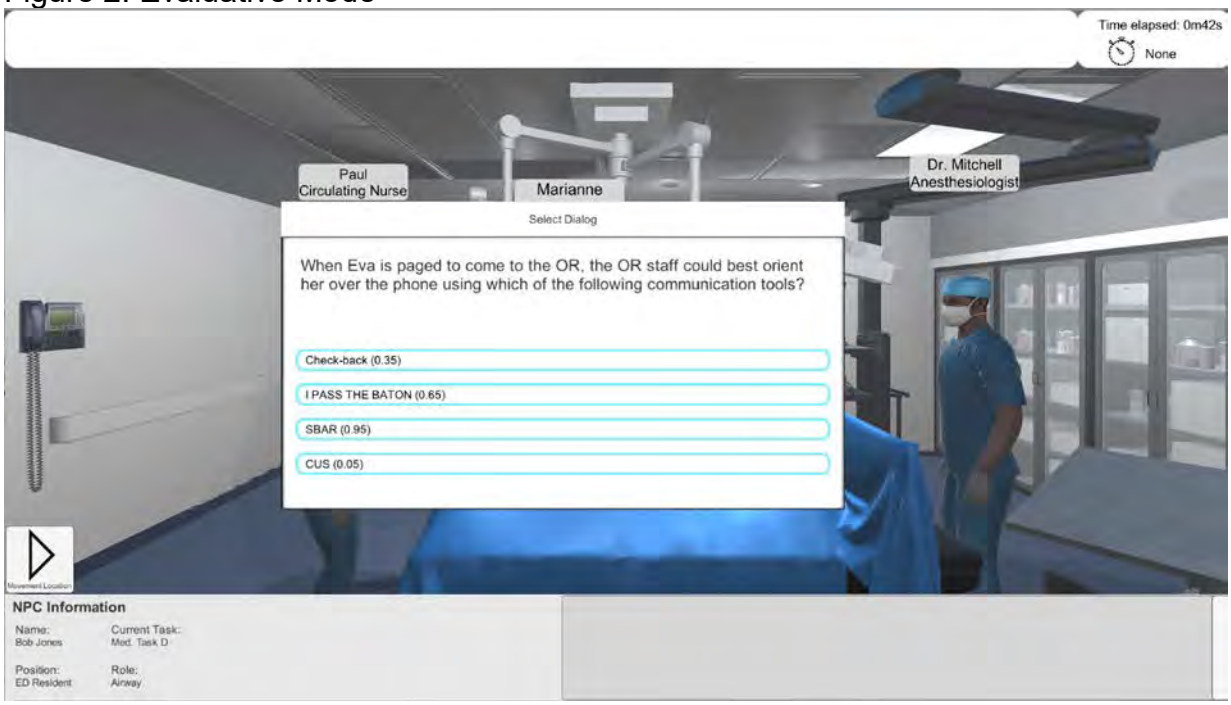
As a researcher, I can change the events that occur in a scenario without recompiling the simulation. Therefore the timeline of events should be read from a database

As a player, I want the simulation to respond appropriately to my input.
As a player, I can cancel entering input after selecting an intention.
As a player, I want the simulation to evaluate my input. The evaluation should account for previously taken actions, information known to me and other characters in the game, and the appropriateness of my input.
As a player, I want the simulation to continue even if I take no action. The simulation should initiate fallback events if an action expected by me does not occur.
As a researcher, I can change the events for each scenario that occur when based on the player's input without recompiling the simulation. Therefore the response events should be read from the database.
As a researcher, I can change the appearance(model/texture) of characters without recompiling the simulation. Therefore appearance data should be read from the DB.
As an instructor, I want the simulation to produce a log of actions taken by the player.
As an instructor, I want the simulation to produce scores for the actions taken by the player.
As a player, I want to see a report about my performance at the end of the simulation.
As a researcher, I can change the medical information that can be known without recompiling the simulation. Therefore a list of medical knowledge should be read from the DB.
As a player, I want the simulation to display the current status of characters whose names I know.
As a player, I can select multiple people to address. Currently I can only select a single person or all people.

Evaluative Mode

Evaluative mode will play back portions of the same scenarios as gameplay mode with actions done both good and poor. The interface for the evaluative mode should look something like the following (Figure 2):

Figure 2: Evaluative Mode



UI Elements

Video Window: Where scenarios unfold

Play/Pause: scenario controls (tab button)

Evaluation Pop-Up Window: Displays a prompt and answer choices. Contains an array of checkboxes for the MC answer choices (multiple choices can be selected) and an OK button.

Scenario Flow

- Participants will be asked to click OK on the consent form after reading what is required for the study
- Participants will be sequenced through 3 scenarios, with instruction/feedback provided in between
- Scenarios and instructional modules will be the same for both groups
- Scenario settings to be represented: ER, OR, ICU
- Total time: approx. 90+ minutes (~ 15 min./scenario; ~ 10 min./instructional module)

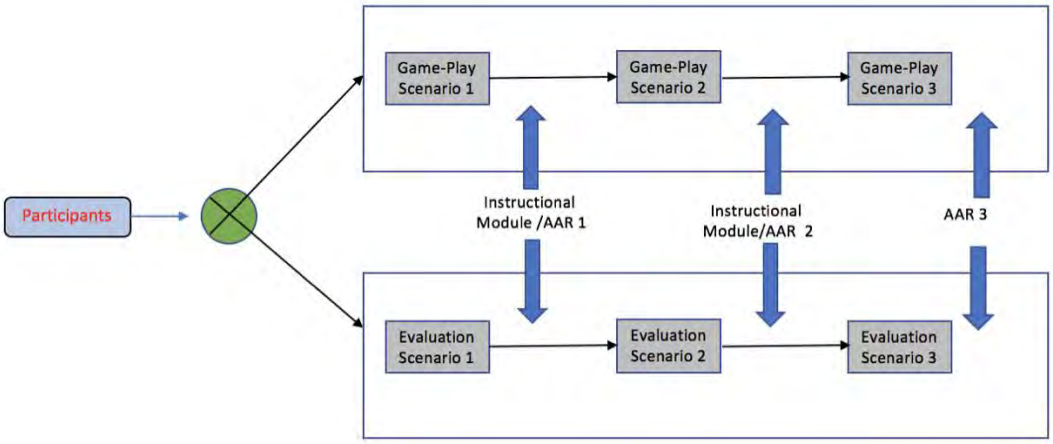


Figure 3. Scenario Flow Chart

After-Action Report

An AAR will be generated at the end of each scenario with feedback on how the student performed. The instruction will include content on all teamwork areas, but may emphasize certain areas in a logical sequence that has been used in prior teamwork training (e.g., TeamSTEPPS).

The following screenshots show the process of the participant going through the AAR. The AAR is triggered each time a scenario is completed.

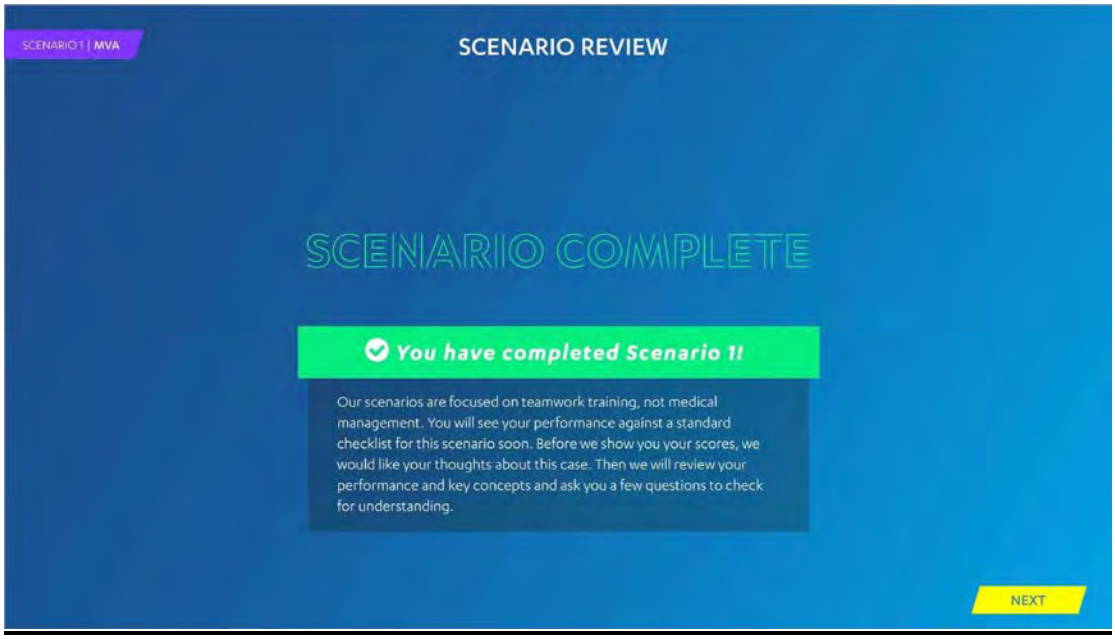


Figure 4. AAR, Page 1. Scenario Complete Screen

Figure 4. AAR, Page 2, Reflection Questions

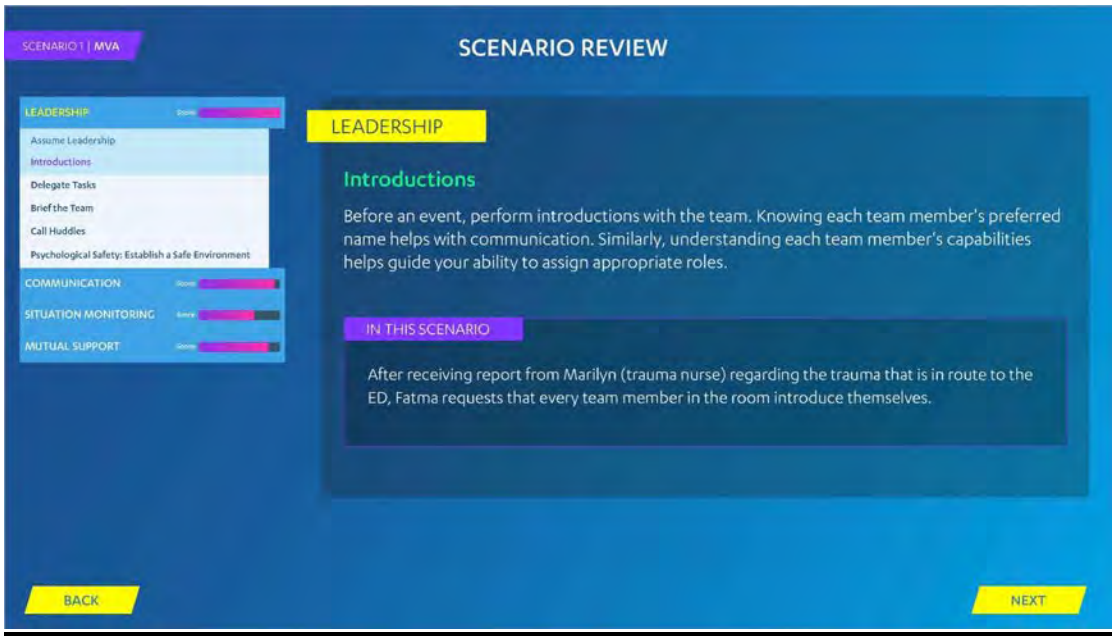


Figure 4. AAR, Page 3, Content Review

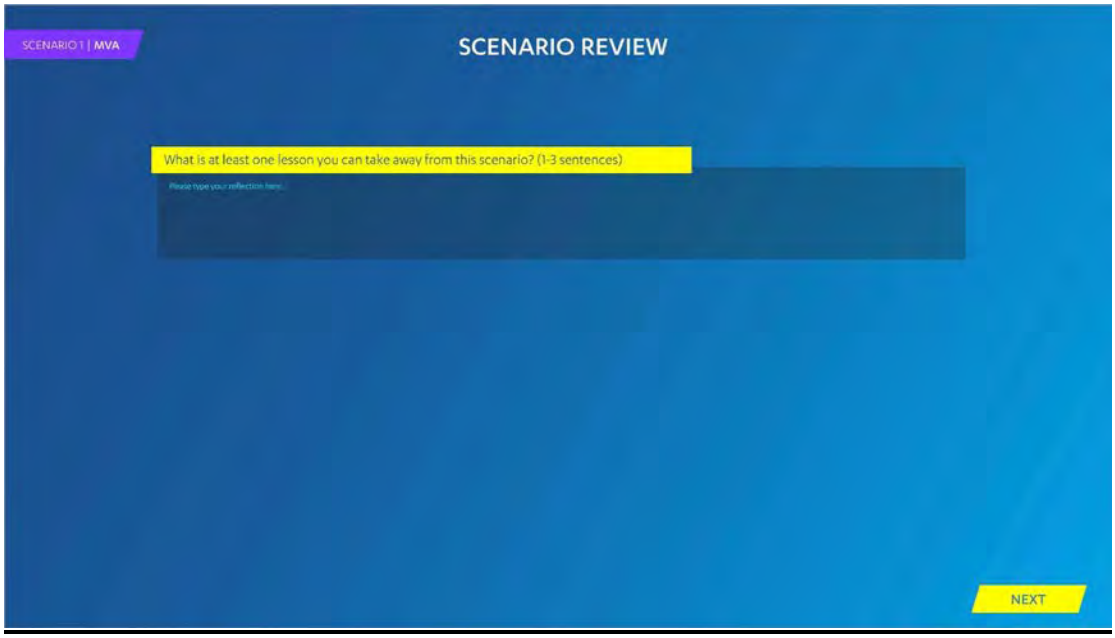


Figure 4 AAR, Page 4, Take Away Lesson

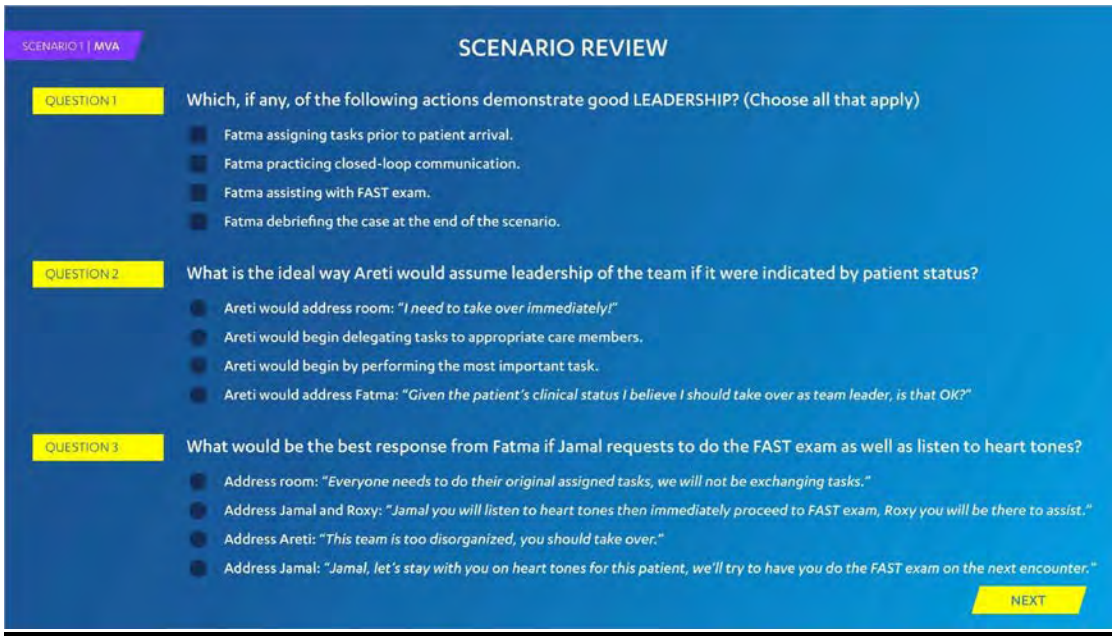


Figure 1. AAR, Page 5, Quiz to Assess if Participant Understood Instruction

Error Handling

If the software crashes, participant should be able to login and navigate to most recent scenario (ideal if system kept track and automatically take them to scenario they were working on)

Help

Help screens will be screenshots of the interface and written instructions on how to carry out different actions (in the gameplay or evaluative mode)

Platforms

Current supported platforms (PC or Mac-based desktop computer).

Not supported: tablet PCs running android or iOS operating systems.

Supported browsers: HTML5 compatible

Configuration Management

Development management will be done using Github or similar repository to maintain core code as well as branches (forks).

Database

A relational database has been created to store all of the sequence of action and events for each scenario, as well as tables for storing the actual gameplay and user input data.

The database model is depicted below in Figure 4.

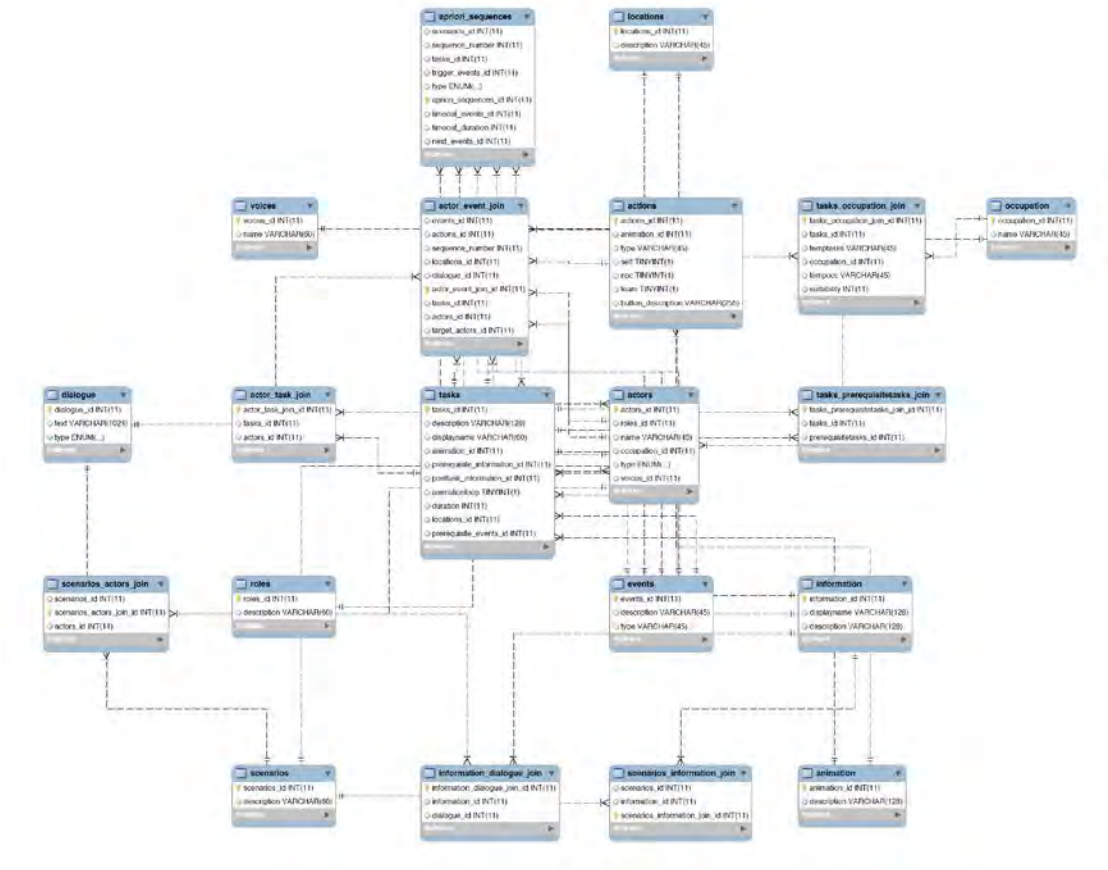


Figure 6. Database model

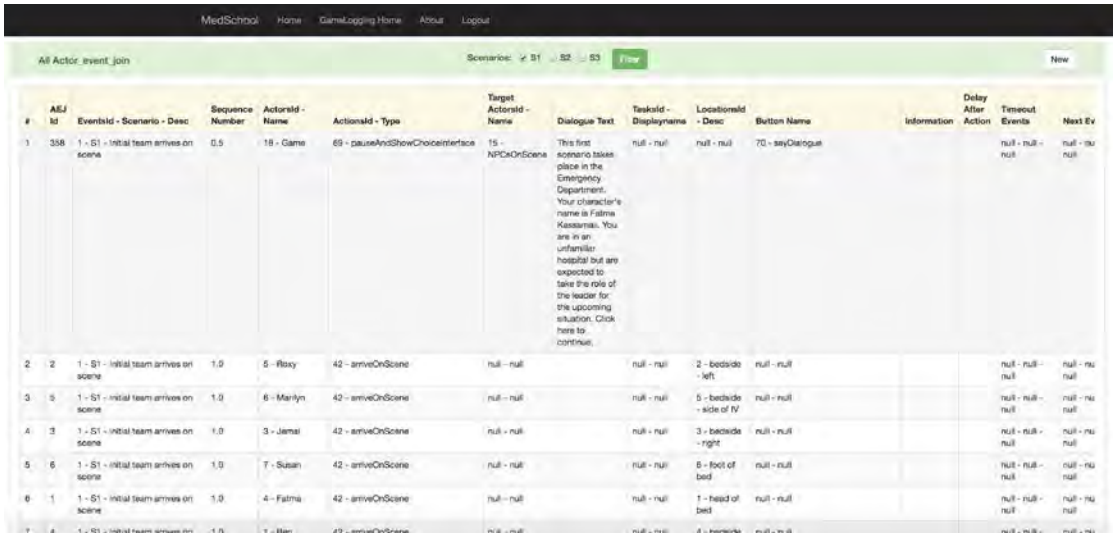


Figure 7. Interface for editing the database

Figure 7 shows the interface for editing the database. The benefit of sourcing in the events and actions, dialogs, etc., is that changes to the database can be immediately instantiated in the game.

AGILE Methodology for Developing a Game-Based Assessment of Teamwork Skills

Authors:
Markus Iseli, Alan D. Koenig, John J. Lee, Rachel Lewin & Randolph Steadman

Abstract

Team training using synthetic, software-based environments is highly desirable to educators. A cornerstone to developing effective team management and behavioral skills is having the ability to practice those skills in fidelity-relevant settings. Synthetic environments in the form of computer-based games or simulations can provide robust, authentic settings in which to teach, practice, and assess team skills. **This paper describes the AGILE methodology employed in the design and development of a screen-based simulation used to train and assess medical personnel to more effectively function as ad-hoc teams in critical-care situations, while also addressing competing stakeholder perspectives and requirements.**

Teamwork Constructs & TeamSTEPPS™

TeamSTEPPS™ is a teamwork system developed by the Department of Defense's Patient Safety Program and the Agency for Healthcare Research and Quality to improve patient safety by improving healthcare professionals' teamwork and communication skills.

The main TeamSTEPPS™ constructs addressed in this project include:

1) **leadership**, including methods for asserting and maintaining leadership of a team
2) **situation monitoring**, the process of "continually scanning and assessing a situation to gain and maintain an understanding of what's going on around you"
3) **communication**, including techniques designed to communicate critical patient information quickly and effectively
4) **mutual support**, the process of assisting teammates to avoid work overload and improve patient safety
5) **psychological safety**, the process of creating a safe environment in which team members feel able to ask for help and raise concerns

Effective teamwork requires an appropriate team member to **establish leadership, maintain awareness of the evolving situation, manage team structure** (i.e., roles, responsibilities, tasks, etc.), and **clearly communicate information and goals**. It also requires that members of the team participate actively in teamwork by utilizing **closed loop communication** and **checkbacks** (i.e. acknowledging what has been said by a teammate and repeating back the information provided), **speaking up** when needed, and maintaining **situational awareness**.

Teamwork in Our Game

Acute care contexts in which game play occurs:

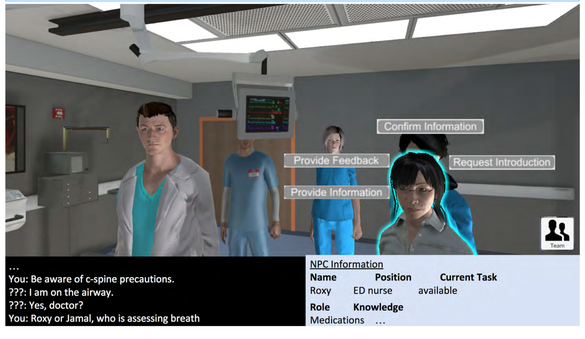
1) Emergency Room
2) Operating Room
3) Intensive Care Unit

Game player assumes role of team leader, and must:

- Assume leadership
- Assign roles and tasks
- Brief the team on the patient and plan at the beginning of the scenario
- Call huddles to update the team's plan and mental model during the scenario
- Provide feedback and closed loop communication as needed during the scenario
- Debrief following the scenario to discuss the teamwork that occurred

Various dialogue options are provided to the game player to assess content and manner of communication

Figure 1: Main interface screen of the game-based assessment of teamwork skills.



Agile Methodology

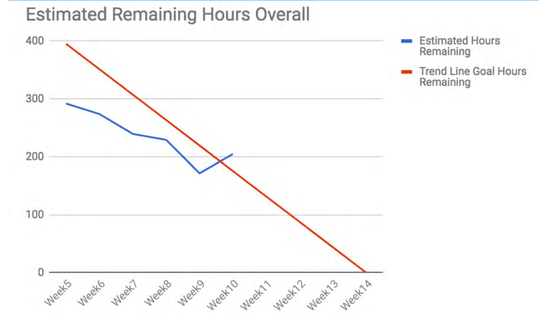
Agile methodology is highly iterative in nature, breaking tasks into small, chunk-sized modules that can be built, tested, and refined.
It allows for all stakeholders to maintain active involvement from the project's start to finish.

To facilitate our Agile process, we used:

- Zoom online meeting software
- Google Docs
- Google Sheets

This allowed our twenty-two member study team—including staff from the UCLA Simulation Center (David Geffen School of Medicine, Departments of General Surgery/Trauma and Anesthesiology), the Graduate School of Education and Information Sciences (GSE&IS), the Center for Research on Evaluation, Standards, and Student Testing (CRESST, GSE&IS), the UCLA Center for Advanced Surgical and Interventional Technology (CASIT), visiting scholars, and SimInsights Inc. (a game development company)—to hold weekly hybrid in-person and virtual meetings. Google Docs and Sheets were used for sharing information, including progress of software development and links to download software builds.

Figure 2: Estimated Remaining Hours Overall (Weeks 5-14)



Structure for Task Breakdown

To break the development of this game down into smaller, more manageable tasks, we used development concepts from Atlassian: **epics and stories.**

Epics are the largest strands of work, comprised of stories.
Stories are descriptions of features or capabilities a stakeholder would want related to the game. For example: "As a player, I need to be able to initiate actions and interact with other non-player characters (NPCs). These include: assume leadership, assemble team, create a shared mental model (brief/huddle/debrief), speak-up, provide acknowledgment, provide encouragement, provide introduction, request introduction, provide information, request information, assign tasks, perform tasks, resolve problems." Stories are comprised of tasks.
Tasks are the lowest level, the individual units of work that must be completed for each story.

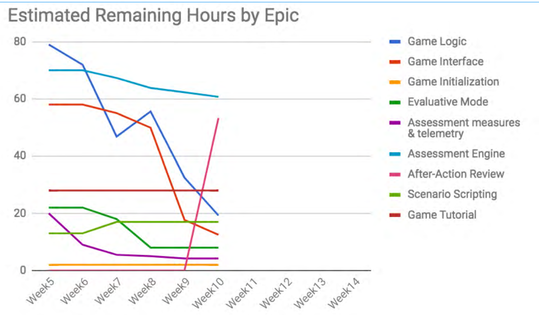
We used the Google sheet to track epics, stories, and tasks and to log the estimated and actual hours of work expended on each task. Due to the iterative nature of the work, the estimated hours shown in Figures 2 and 3 changed and were updated as additional subtasks were identified. For example, the spike in hours for the after-action review (AAR) between weeks nine and ten was due to gaining a better understanding of what programming would be involved, such as feeding scored performance data from the database via an application programming interface (API) to the AAR interface.

Breakdown by Epic

Nine epics were identified which comprise the total scope of development work:

Game Logic:	Game initialization, scenario progression, and handling of player input/actions
Game User Interface	Availability of affordances that enable the player to take various actions including moving around the space and interacting with non-player characters (NPCs)
Evaluative Mode	Scenario playback in an alternative mode that uses the same game environment but where the player acts as a critical observer
Assessment Measures and Telemetry	Definition of assessable moments or meaningful actions that are used to determine a player's competency across the main teamwork skills
Assessment Engine	A Bayesian inference probabilistic model built from ontologies related to teamwork skills
After-Action Review	Reflection, assessment feedback, and instruction on teamwork skill
Scenario Scripting	Definition of team members, their roles, and actions that they would take in ideal and problematic cases
Game Tutorial	An introduction to the game mechanics and interface to help the player learn how to move, monitor statuses, and take actions in the game

Figure 3. Estimated Remaining Hours by Epic (Weeks 5-14)



Lessons Learned: Pros & Cons

Pros:

- Easy to identify, design, and test ideas quickly
- Efficient platform for incorporating competing stakeholder requirements
- Allows unforeseen issues to surface early
- Provides for low-cost corrective action when problems arise

In terms of challenges, the development process required more transparency around the fourth week, and a process was put in place, instantiated in a Google sheet, to define the remaining tasks into stories and epics , list who they were assigned to, and to track and monitor progress. It is important to include an estimation of the time required for project management oversight, including maintenance of the tasks in the Google sheet or similar tracking software.

Cons:

- Must be certain to include sufficient transparency and accountability
- Must estimate project management, administrative, and oversight time in addition to development time

Key takeaway: The iterative nature of the AGILE process allows for more frequent review cycles which facilitates getting to the desired goal state quicker and at lesser expense. This approach offers utility not only to our team training simulation, but to any pedagogical simulation development.

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